Chapter 9

Optimal Power Flow with TCSC and TCPS Modeling using Craziness and Turbulent Crazy Particle Swarm Optimization

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ABSTRACT

This paper presents two new Particle swarm optimization methods to solve optimal power flow (OPF) in power system incorporating flexible AC transmission systems (FACTS). Two types of FACTS devices, thyristor-controlled series capacitor (TCSC) and thyristor controlled phase shifting (TCPS), are considered. In this paper, the problems of OPF with FACTS are solved by using particle swarm optimization with the inertia weight approach (PSOIWA), real coded genetic algorithm (RGA), craziness based particle swarm optimization (CRPSO), and turbulent crazy particle swarm optimization (TRPSO). The proposed methods are implemented on modified IEEE 30-bus system for four different cases. The simulation results show better solution quality and computation efficiency of TRPSO and CRPSO algorithms over PSOIWA and RGA. The study also shows that FACTS devices are capable of providing an economically attractive solution to OPF problems.

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INTRODUCTION

Flexible AC transmission systems (FACTS) devices are integrated in power systems to control power flow, increase transmission line capability to its thermal limit, and improve the security of transmission systems. In addition to controlling the power flow in specific lines, FACTS devices could be used to minimize the total generator fuel cost in optimal power flow (OPF) problem. In OPF the main objective is to minimize the costs of meeting the load demand for the power system while satisfying all the security constraints. Traditional optimization techniques such as linear Programming (Taranto, Pinto, & Pereira, 1992; Ge & Chung, 1998; Ge & Chung, 1999), Newton Rapshon method (Fuerte-Esquivel, Acha, Tan, & Rico, 1998; Fuerte-Esquivel, Acha, & Ambriz-Perez, 2000a; Fuerte-Esquivel, Acha, & Ambriz-Perez, 2000b) and Newton’s method (Ambriz-Perez, Acha, Fuerte-Esquivel, & De la Torre, 1998; Ambriz-Perez, Acha, & Fuerte-Esquivel, 2000) are used to solve the problem of OPF with FACTS assuming continuous, differentiable and monotonically increasing cost function. However, these methods have failed in handling non-convex and nonlinear engineering optimization problems and tend to get stuck at local optimum solutions. Since OPF incorporating FACTS devices with valve point discontinuities is a highly non-linear problem with non-differentiable feature, stochastic search algorithms such as GA (Ippolito, Cortiglia, & Petrocelli, 2006; Chung & Li, 2001; Cai & Erlich, 2003; Leung & Chung, 2000; Narmatha Banu & Devaraj, 2008), particle swarm optimization (PSO) (Benabid, Boudour, & Abido, 2009; Hu & Eberhart, 2002; Mollazei, Forsangi, Nezamabadi-pour, & Lee, 2007; Saravanan, Slochanal, Venkatesh, Stephen, & Abraham, 2007), differential evolution (DE) (Basu, 2008), tabu search (TS) & simulated annealing (SA) (Bhasaputra & Ongsakul, 2002), evolutionary programming (EP) (Ma, 2003), ant colony optimization (ACO) (Song, Chou, & Stonham, 1999) and bacteria foraging optimization (BFO) (Ghoshal, Chatterjee, & Mukherjee, 2009) are used as techniques to solve problems of OPF incorporating FACTS.

Amongst the above population based algorithms, the annealing schedule of SA should be tuned carefully; otherwise it may produce suboptimal solutions. The GA method is usually faster than SA method because GA has parallel search technique. Traditional GA also differs from EP in two aspects; EP primarily relies on mutation and selection, but no crossover like traditional GA and EP uses the real values of control parameters but not their coding as in traditional GA. Hence, considerable computation time may be saved in EP. Real coded GA (RGA) (Gaing & Huang, 2004) has been introduced to solve the OPF problems more efficiently with significant reduction in the computation time. ACO is based on foraging behavior of ant species. Solution candidates, called ants in ACO, communicate with other members of the ant colony by depositing pheromone to mark a path. High concentrations of pheromones indicate more favorable paths that other members should follow in order to reach the optimal solution. BFO is a bio-inspired technique, applied to solve power system optimization problems by Ghoshal et al. (Ghoshal, Chatterjee, & Mukherjee, 2009), but its optimization time is very high. PSO is one of the modern heuristic algorithms and has a great potential to solve complex optimization problems. PSO algorithm is highly robust yet remarkably simple to implement Thus, it has become usual to apply the PSO, with more new modifications (Roy, Ghoshal, & Thakur, 2009a; Roy, Ghoshal, & Thakur, 2009b) in velocity, to achieve better optimization and handle the power system problems more efficiently. But conventional PSO also suffers from achieving the global best solution in possible shortest time.

In this paper two new PSO algorithms have been employed which are more effective and capable of solving nonlinear optimization problems faster and with better accuracy in detecting the