Chapter 1
An Improved Particle Swarm Optimization for Optimal Power Flow

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ABSTRACT

This chapter proposes a newly improved particle swarm optimization (IPSO) method for solving optimal power flow (OPF) problem. The proposed IPSO is the particle swarm optimization with constriction factor and the particle's velocity guided by a pseudo-gradient. The pseudo-gradient is to determine the direction for the particles so that they can quickly move to optimal solution. The proposed method has been tested on benchmark functions, the IEEE 14-bus, IEEE 30-bus, IEEE 57-bus, and IEEE-118 bus systems, in which the IEEE 30-bus system is tested with different objective functions including quadratic function, valve point effects, and multiple fuels. The test results have shown that the proposed method can efficiently obtain better total costs than the conventional PSO method. Therefore, the proposed IPSO could be a useful method for implementation in the OPF problem.

INTRODUCTION

The objective of an optimal power flow (OPF) problem is to find the steady state operation point of generators in the system so as their total generation cost is minimized while satisfying various generator and system constraints such as generator's real and reactive power, bus voltage, transformer tap, switchable capacitor bank, and transmission line capacity limits. In the OPF problem, the controllable variables usually determined are real power output of generators, voltage magnitude at generation buses, injected reactive power at compensation buses, and transformer tap settings. Traditionally, mathematical programming techniques can effectively deal with

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the problem. However, due to the incorporation of FACTS devices to systems, valve point effects or multiple fuels to generators recently, the OPF problem becomes more complicated and the mathematical programming techniques are not a proper selection. Therefore, it requires more powerful search methods for a better implementation. Due to its importance, the OPF problem has been widely studied in the world (Happ & Wirgau, 1981; Huneault, & Galiana, 1991; Momoh, Adapa & El-Hawary, 1999a; Adapa & El-Hawary, 1993b; Pandya & Joshi, 2008).

The OPF problem has been solved by several conventional methods such as gradient-based method (Wood & Wollenberg, 1996), linear programming (LP) (Abou El-Ela & Abido, 1992; Mota-Palomino & Quintana, 1986), non-linear programming (NLP) (Dommel & Tinny, 1968; Pudjianto, Ahmed, & Strbac, 2002), quadratic programming (QP) (Burchett, Happ & Vierath, 1984; Granelli & Montagna, 2000), Newton-based methods (Sun *et al*., 1984; Santos & da Costa, 1995; Lo & Meng, 2004), semidefinite programming (Bai *et al.*, 2008), and interior point method (IPM) (Yan & Quintana, 1999; Wang & Liu, 2005; Capitanescu *et al.*, 2007). Generally, the conventional methods can find the optimal solution for an optimization problem with a very short time. However, the main drawback of these methods is that they are difficult to deal with non-convex optimization problems with non-differentiable objective. Moreover, these methods are also very difficult for dealing with large-scale problems due to large search space. Meta-heuristic search methods recently developed have shown that they have capability to deal with this complicated problem. Several meta-heuristic search methods have been also widely applied for solving the OPF problem such as genetic algorithm (GA) (Lai & Ma, 1997; Wu, Cao & Wen, 1998; Osman, Abo-Sinna & Mousa, 2004), simulated annealing (SA) (Roa-Sepulveda & Pavez-Lazo, 2003), tabu search (TS) (Abido, 2002), evolutionary programming (EP) (Wu & Ma, 1995; Yuryevich & Wong, 1999), particle swarm optimisation (PSO) (Abido, 2001), and differential evolution (DE) (Cai, Chung & Wong, 2008). These meta-heuristic search methods can overcome the main drawback from the conventional methods with the problem not required to be differentiable. However, the optimal solutions obtained by these methods for optimization problems are near optimum and quality of the solutions is not high when they deal with large-scale problems; that is the obtained solutions may be local optimums with long computational time. In addition, the hybrid methods have also developed for solving OPF problem such as hybrid TS/SA (Ongsakul & Bhasaputra, 2002), hybrid GA-IPM (Yan *et al*., 2006), hybrid differential evolution (Li, Zhao & Chen, 2010), and hybrid of fuzzy and PSO (Liand *et al.*, 2011). The purpose of the hybrid methods is to utilize the advantages of the element methods integrated in it for obtaining better optimal solutions. Although the hybrid method can be better than the single methods in finding optimal solution they can be slower the single methods due to combination of many single methods. Moreover, the hybrid methods are also usually more complex than the single methods.

In this chapter, a newly improved particle swarm optimization (IPSO) method is proposed for solving optimal power flow (OPF) problem. The proposed IPSO is the particle swarm optimization with constriction factor and the particle's velocity guided by a pseudo-gradient. The pseudo-gradient is to determine the direction for the particles so that they can quickly move to optimal solution. The proposed method has been tested on benchmark functions, the IEEE 14-bus, IEEE 30-bus, IEEE 57-bus, and IEEE-118 bus systems, in which the IEEE 30-bus system is tested with different objective functions including quadratic function, valve point effects, and multiple fuels. The results from the proposed IPSO are also validated by comparing to those from the conventional PSO.

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