Chapter 43
Multi-Objective Generation Scheduling Using Genetic-Based Fuzzy Mathematical Programming Technique

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ABSTRACT

This chapter presents a solution for multi-objective Optimal Power Flow (OPF) problem via a genetic fuzzy formulation algorithm (GA-FMOPF). The OPF problem is formulated as a multiple objective problem subject to physical constraints. The objectives and constraints are modelled as fuzzy mathematical programming problems involving the minimization of the objective function with fuzzy parameters and uncertainties in set of constraints. So the method is capable of representing practical situations in power system operation where the limits on specific variables are soft and the small violations of these limits may be tolerable. Then, genetic algorithm is used in order to seek a feasible optimal solution to the environmental/economic dispatch problem. Illustrative examples are given to clarify the proposed method developed in this manuscript and the performance of this solution approach is evaluated by comparing its results with that of their existing methods.

INTRODUCTION

Electric power systems are, perhaps, the most challenging industrial systems in term of task of planning and operating. These tasks demand acknowledge of the priorities and objectives involved. The basic requirement is to meet the demand for electric energy for the served area at the lowest possible cost. Another objective is to minimize the environmental impact of the operation. Continuity of service and reliability are major considerations. Safety for both personnel and equipment is a factor that may over-

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ride some of the other objectives. The constraints include inequality ones which are the limits of control variables and state variables; and equality ones which are the power flow equations.

The goal of Optimal Power Flow (OPF), first introduced by Carpentier in 1962, is to find optimal settings of a given power system network that optimize the system objective functions such as total generation cost, system loss, emission of generating units, and load shedding while satisfying power flow equations, system security, and equipment operating limits. Different control variables, some of which are generators' real power outputs and voltages, are manipulated to handle large-scale power systems in an effective and efficient manner (Parti, et al., 1983; Saadat, 1999; Naarayan, 2003). In its most general formulation, OPF is a nonlinear, non-convex, large-scale, static optimization problem, with both continuous and discrete control variables. The idea behind the combined economic and emission OPF is to compute the optimal generation for individual units of the power system by minimizing the fuel cost and emission levels simultaneously, subject to various system constraints.

A number of conventional optimization techniques have been utilized for solving the OPF problem, for instance: equal incremental cost method, sequential quadratic programming, decomposition method, Lagrangian relaxation method, and Newton methods (Kothari & Parmar, 2006). Although some of these techniques have good convergences' characteristics, some of their major drawbacks are related to their convergence to local solution instead of global ones, if the initial guess is located within a local solution neighbourhood. The theoretical assumptions behind such algorithms may be not suitable for the OPF formulation. Optimization methods such as Simulated Annealing (SA) (Vasant, & Barsoum. 2010; Vasant, 2010; Aminian, Javid, Asghari, Gandomi, & Esmaeili, 2011), Evolutionary Programming (EP) (Tsoulos, & Vasant, 2010; Al-Obeidat, Belacel, Carretero, & Mahanti, 2011), Genetic Algorithms (GA) (Dieu, & Ongsakul, 2010) and Particle Swarm Optimizer (PSO) (Polprasert, Ongsakul, & Dieu, 2013; Dieu, & Schegner, 2012; Vo & Schegner, 2013) have been employed to overcome such drawbacks. Recent strategies have begun to emerge as a very promising alternative to overcome common difficulties of the previously-mentioned algorithms (Galiana & Conejo, 2009).

In crisp formulation of the OPF problem, operating parameters are assumed to be deterministic, but In real world OPF problems, input data or related parameters, such as market demand, capacity, and relevant operating costs, frequently are fuzzy owing to some information being incomplete or unobtainable (Galiana & Conejo, 2009). As example of constraints/objectives with Fuzziness we have: acceptable security risk, assessment of customer satisfaction, economic objectives, environmental objectives, equipment loading limits, normal operational limits, and so forth. Because of not enough information, none of these constraints or objectives is well defined. When deterministic constraints are not satisfied in the conventional mathematical programming, it is difficult to learn what kind of constraints is critical to what extent (Kothari & Singh Parmar, 2006; Galiana & Conejo, 2009).

In the formulation of the OPF problem a major source of imprecision or fuzziness exists in the evaluation of the constraints. In traditional optimization algorithms, constraints are satisfied within a tolerance defined by a crisp or nonfuzzy number. In reality and engineering practice this evaluation involves many sources of approximation. A design is commonly considered satisfactory when the constraints are satisfied within a given predetermined tolerance. When an optimization algorithm satisfies the constraints exactly (within the small tolerance of numerical computations) it can miss the true optimum solution within the confine of practical and realistic approximations. It will be demonstrated that by taking into account the fuzziness and imprecision in the constraints and employing the fuzzy set theory it is possible to substantially increase the probability of finding the actual global OPF solution (Pajan, & Paucar, 2002; Madouh & El-Hawary, 2004; Hongbo, Yu, & Yongsheng, 2000).