Chapter 3.14

Congestion Management Using Hybrid Particle Swarm Optimization Technique

Sujatha Balaraman
Government College of Engineering, India

N. Kamaraj
Thiagarajar College of Engineering, India

ABSTRACT

This paper proposes the Hybrid Particle Swarm Optimization (HPSO) method for solving congestion management problems in a pool based electricity market. Congestion may occur due to lack of coordination between generation and transmission utilities or as a result of unexpected contingencies. In the proposed method, the control strategies to limit line loading to the security limits are by means of minimum adjustments in generations from the initial market clearing values. Embedding Evolutionary Programming (EP) technique in Particle Swarm Optimization (PSO) algorithm improves the global searching capability of PSO and also prevents the premature convergence in local minima. A number of functional operating constraints, such as branch flow limits and load bus voltage magnitude limits are included as penalties in the fitness function. Numerical results on three test systems namely modified IEEE 14 Bus, IEEE 30 Bus and IEEE 118 Bus systems are presented and the results are compared with PSO and EP approaches in order to demonstrate its performance.

INTRODUCTION

Deregulation is a new paradigm in the electric power industry. The goal of deregulation is to enhance competition and bring consumer's new choices and economic benefits. Power system security, congestion management, power quality and power regulations are major concepts that draw the attention of power researchers in deregulated surroundings. In deregulated electricity market, most of the time power system operates near its

rated capacity as each player in the market is trying to gain as much as possible by full utilization of existing resources. Congestion in the transmission lines is one of the technical problems that appear particularly in the deregulated environment. Congestion management methods reported in literature are as follows.

OPF based Congestion management is proposed in (Alfredo, Cuello-reyna, & Jose, 2005) using differential evolution as an optimization tool. (Conejo, Milano, & Garcia-Bertrand, 2006) addressed congestion management using classical approach considering voltage stability. Congestion management based on multi objective particle swarm optimization method is reported by (Hazra & Sinha, 2007; Dutta & Singh, 2008) discussed congestion management by optimal rescheduling of generators using PSO. However security loading margin is not considered. Multi objective market clearing procedure is discussed by (Milano, canizares, & Invernizzi, 2003). Moreover this work does not give marginal prices directly since the objective function is neither a cost nor a social welfare, whereas the technique used in our paper computes marginal prices directly, if applied to the market-clearing problem. Congestion management based on sensitivity methods are reported in (Christie, Wollenberg, & Wangensteen, 2000; Singh, Hao, & Papalexopoulos, 1998; Sinha & Hazarika, 2001). Congestion management based on optimum generation rescheduling and load shedding schemes are reported in (Sinha & Hazarika, 2001; Talukdar, Sinha, Mukhopadhyay, & Bose, 2005. Reference (Kumar, Srivastava, & Singh, 2004) proposed zonal based congestion management approach, where zones are determined based on transmission congestion distribution factors.

Since the proposed problem is a complex, combinatorial optimization problem use of heuristic algorithm is inevitable. Population based co-operative and competitive stochastic search algorithms are very popular in the recent years in the research area of computational intelligence.

Careful survey on literature reveals that the application of Genetic Algorithm and Evolutionary Programming, PSO are successfully implemented to solve complex problems such as congestion management in efficient and effective manner. These techniques do not depend on the first and second derivatives of the objective function of the problem to be optimized Most of the population based search approaches are motivated by evaluation as seen in nature. Evolutionary Programming is a technique based on the mechanics of natural selections. It is a powerful and general global optimization method (Xin, Yong, & Guangming, 1999). EP can provide a good solution even the problem has many local optimum solutions at the beginning. Application of EP in the field of Power Systems is reported in (Wong & Yuryevich, 1998; Pathom, Hiroyuki, Eiichi, & Jun Hasegawa, 2002; Somasundaram & Kuppusamy, 2005).

The PSO algorithm was first introduced by Eberhart and Kennedy (1995). PSO is yet another optimization algorithm that falls under the soft computing umbrella that covers genetic and evolutionary algorithm as well. Unlike in genetic algorithms, evolutionary programming, and evolution strategies, in PSO, the selection operation is not performed. Also PSO technique can generate a high-quality solution within shorter calculation time and stable convergence characteristic than other stochastic methods (Eberhart & Kennedy, 1995; Shi & Eberhart, 1998). References (Saravanan, Slochanal, Venkatesh, & Abraham, 2007; Lee, 2007; Yoshida, Kawata, & Fukuyama, 2000) provide application of PSO to various Power System problems. (Ahmed, Germano, & Antonio, 2005) propose hybrid PSO method for loss minimization problem.

This paper proposes a new approach for solving transmission congestion management problem using hybrid particle swarm optimization technique for a pool based day-ahead electric energy market. In the proposed approach the global searching capability is improved by embedding EP in PSO

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