Transient Stability Constrained Optimal Power Flow Using Teaching Learning Based Optimization

Aparajita Mukherjee, Department of Electrical Engineering, Indian School of Mines, Dhanbad, India

Sourav Paul, Department of Electrical Engineering, Dr. B. C. Roy Engineering College, Durgapur, India

Provas Kumar Roy, Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri, India

ABSTRACT

Transient stability constrained optimal power flow (TSC-OPF) is a non-linear optimization problem which is not easy to deal directly because of its huge dimension. In order to solve the TSC-OPF problem efficiently, a relatively new optimization technique named teaching learning based optimization (TLBO) is proposed in this paper. TLBO algorithm simulates the teaching–learning phenomenon of a classroom to solve multi-dimensional, linear and nonlinear problems with appreciable efficiency. Like other nature-inspired algorithms, TLBO is also a population-based method and uses a population of solutions to proceed to the global solution. The authors have explained in detail, the basic philosophy of this method. In this paper, the authors deal with the comparison of other optimization problems with TLBO in solving TSC-OPF problem. Case studies on IEEE 30-bus system WSCC 3-generator, 9-bus system and New England 10-generator, 39-bus system indicate that the proposed TLBO approach is much more computationally efficient than the other popular methods and is promising to solve TSC-OPF problem.

Keywords: *Evolutionary Algorithms, Optimal Power Flow, Teaching Learning Based Optimization, Transient Stability*

1. INTRODUCTION

A power system is a network through which energy is transferred from generators to loads. Energy transformation from generators to loads takes place through the power system network. Because of larger power transfers over longer distances, complex coordination, difficult interaction among various system controllers and less power reserves, complexity is gradually increasing for planning and operation purpose of modern power system network. Secure and reliable operation of the power system has always been a top priority for system

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operators. Power system is said to be secure when it is able to withstand sudden disturbances with minimum loss of the quality of service i.e. whenever disturbance occurs, the system survives the ensuing transient and moves into a suitable stable condition where all operating constraints are within limits.

Optimal power flow (OPF) is an important tool for power system operation, control and planning. It was first introduced by (Dommel and Tinney, 1968). The main purpose of an OPF program is calculating the optimal operating point of a power system and setting the variables that optimize a certain objective function while satisfying power flow equations and inequality constraints, such as system security and equipment operating limits by (Chen, Tada, Okamoto, Tanabe, & Ono, 2001; El- Hawari, 1996; Laufenberg, & Pai, 1998; Yan, Xiang, & Zhang, 1996).

Among various OPF problems, the OPF with transient stability constraints research is an interesting problem, since it not only considers some optimal strategies but also includes all security and stability constraints. Transient stability constraints describe about the limits that system dynamics must satisfy during transient conditions to be stable. The cost of losing synchronous through a transient instability is extremely high in modern power systems.

Transient stability constrained optimal power flow (TSC-OPF) is an effective measure to coordinate the security and economic of power system. The main aim behind the transient stability-constrained OPF (TSC-OPF) is to integrate economic objectives and both steady-state and stability constraints in one unique formulation. TSCOPF is a large-scale nonlinear optimization problem with both algebraic and differential equations developed by Sauer and Pai (1998), Kundur (1994) and Stott (1979). One method is to simplify TSCOPF problem by converting the differential equations into equivalent algebraic equations as inequality constraints and then integrated the TSCOPF as an algebraic optimization problem which can be solved by Gan, Thomas, and Zimmerman (2000) through conventional optimization techniques. Based upon this, multicontingency concept has come from Yuan, Kubokawa, and Sasaki (2003) which gave a modified formulation for integrating transient stability model into conventional OPF that reduces the calculation load considerably. But it faces some obligations that due to a large number of variables not only convergence problem but also computation inaccuracy occur for approximation. Now for solving this infinitesimal dimension of TSCOPF problem to finite dimensional problem, a new technique, functional transformation technique is proposed by Chen, Tada, Okamoto, Tanabe, and Ono (2001). But unfortunately, these methods are infeasible in practical systems because of high sensitivity problem of initial conditions. Owing to the computational difficulties, the degree of freedom in the objective functions and the types of constraints in OPF problems such as transient stability limit are restricted. Thus, it becomes necessary to develop optimization techniques that are capable of overcoming these drawbacks and handling such difficulties. Some of the population-based optimization methods that have been successfully applied to TSCOPF problems are improved genetic algorithm by Chan, Ling, Chan, Iu, and Pong (2007), particle swarm optimization by (Mo, Zou, Chan, & Pong, 2007), differential evolution by Cai, Chung, and Wong (2008) and the artificial bee colony (ABC) by Karaboga (2005).

Recently, a new optimization technique, Teaching Learning Based Optimization is introduces by Rao, Savsani, and Vakharia (2011) that requires only common controlling parameters like population size and number of generations for its working. Some research work has been done on the proposed method, Mandal, and Roy (2013), Roy, and Bhui (2013) and Roy, Paul, and Sultana (2014). But dealing of TLBO with TSCOPF problem is a totally new concept and has not been used before. It improves the quality of the solution and the corresponding computational results show the superiority of the proposed algorithm.

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