

Chapter 14

Cuckoo Search Algorithm for Hydrothermal Scheduling Problem

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ABSTRACT

This chapter proposes a Cuckoo Search Algorithm (CSA) and a Modified Cuckoo Search Algorithm (MCSA) for solving short-term hydrothermal scheduling (ST-HTS) problem. The CSA method is a new meta-heuristic algorithm inspired from the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of other host birds of other species for solving optimization problems. In the MCSA method, the eggs are first classified into two groups in which ones with low fitness function are put in top group whereas others with higher fitness function are put in abandoned group. In addition, an updated step size in the MCSA changes and tends to decrease as the iteration increases leading to near global optimal solution. The robustness and effectiveness of the CSA and MCSA are tested on several systems with different objective functions of thermal units. The results obtained by the CSA and MCSA are analyzed and compared have shown that the two methods are favorable for solving short-term hydrothermal scheduling problems.

INTRODUCTION

Electrical energy is one of the most popular and economic energies due to its easy production at high performance and its reasonable cost. Development of a country's economy is partially dependent on the country's electrical energy improvement policy. In fact, most of developing and developed countries are focusing on industry such as producing car, machine, etc. consuming a large number of electricity among total generated energy. Therefore, a main task is to establish electrical power systems which have to work flexibly, continually and economically. Thermal plants using fossil fuel account for large rate

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power plants among several kinds of electrical power plants including conventional plants like thermal plants and hydro plants, and renewable energy based ones like wind power plants, solar power plants, photovoltaic, etc.

Planning optimal operation of isolated or inter connected power systems show a large variety of challenging problems, the solution of which requires application of several mathematical techniques from various branches of it. In power system optimization operation, there is a set of many available power plants which are being waiting for operation from experts. The task is to determine how many Megawatts each plant should supply to power system grid and transfer to customer load. The problem has been formulated as an optimization problem containing an objective function and equality constraints and inequality constraints. As the objective function is obtained, it means that fuel cost for producing electricity at thermal plants is minimized and all equality constraints and inequality constraints are satisfied over considered schedule time. This problem is defined as an economic load dispatch problem.

For a larger power system, both all thermal plants and hydro plants are connected via transmission line. The optimal operation task of the system has become more complicated since the hydro plants had a significant contribution to total electrical energy supplying to load. In fact, there are several complex constraints in hydro plants including equality constraint such as available water volume and inequality constraints such as upper and lower limits on power output of generator, on water discharges and on reservoir volume. However, the objective function of the hydro plants can be ignored as their primary fuel for producing electricity, water, is considered negligible. Therefore, the objective function of hydro-thermal scheduling problem is also to minimize fuel cost of thermal plants while satisfying all constraints of the hydrothermal system such as load balance constraint, available water constraint, maximum and minimum limits on thermal and hydro generations, on water discharge and on volume reservoir.

Several conventional methods have been used to solve the short-term hydrothermal scheduling problem such as Newton method since the end of twentieth century (Zaghlool & Trutt, 1988; Basu, 2003), method based on the combination of Lagrange function and Newton method (Rashid & Nor, 1991), lambda-gamma iteration method (Wood & Wollenberg, 1996), dynamic programming (DP) (Wood & Wollenberg, 1996), gradient search technique (GS) (Wood & Wollenberg, 1996), mixed integer programming (MIP) (Nilsson & Sjølvgren, 1996), decomposition and coordination method (Li, Svoboda, Chung-Li Tseng & Johnson, 1997), Lagrange relaxation (LR) (Salam Nor KM, Hamdan, 1998; Xiaohong, Luh & Zhang, 1995; Al-Agtash, 2001), network flow (Franco, Carvalho & Soares, 1994; Heredia & Nabona, 1995; Oliveira & Soares, 1995), hydrothermal scheduling algorithm (HSA) (Carvalho & Soares, 1987), peak shaving (Simopoulos, Kavatza & Vournas, 2007), and progressive optimality algorithm (Nanda & Bijwe, 1981). The conventional methods have the same characteristic that the objective function and all constraints have to be represented as piecewise linear or differentiable functions. The manner means that applicability of the methods are restricted on problems with more complex objective function considering valve point loading effect and complex constraints.

In recent years, many meta heuristic algorithms have been proposed for solving the HTS problem such as simulated annealing approach (SA) (Wong & Wong, 1994), evolutionary programming (EP) (Yang, Yang & Huang, 1996; Hota, Chakrabarti & Chattopadhyay, 1999; Sinha, Chakrabarti & Chattopadhyaya, 2003; Türkay, Mecitoğlu & Baran, 2011), genetic algorithm (GA) (Chan & Chang, 1996; Orero & Irving, 1998; Gil, Bustos & Rudnick, 2003; Sasikala J, Ramaswamy, 2010, Kumar & Naresh, 2007), Hopfield neural network (HNN) (Basu, 2003), differential evolution (DE) (Lakshminarasimman & Subramanian, 2006), particle swarm optimization (PSO) (Yu, Yuan & Wang, 2007, Mandal, Basu &

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