Chapter 15
Modern Methods of Optimization in Models of Hydrothermal Coordination and Emission of Contaminating Particles in Power-Generating Plants

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ABSTRACT

The problem of hydrothermal coordination is a classic example of nonlinear and large-scale dynamic mathematical optimization that involves the problem of the economic dispatch plus other constraints associated with the coordination of a pair of systems integrated into a network (i.e., the production of energy from thermoelectric and hydroelectric plants). A large number of methods and models that represent this problem, from classical methods of optimization to modern methods based on metaheuristics, exist. In this chapter, the classic structure of the problem is analyzed and new constraints are proposed, including those based on the level of customer service. Some recent modern formulations of the model are shown, and the existing literature is reviewed showing the modern methods of optimization based on heuristics. The authors illustrate it by optimizing an instance consisting of three thermo plants and three hydro plants through random search and genetic algorithm.

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INTRODUCTION

The problem of hydrothermal coordination is a classic problem in the literature of both nonlinear mathematical programming and electrical engineering. From an optimization point of view, the problem presents several areas of opportunity due to the complex nature of the same and the fact that new randomness inherent in models such as maintenance shutdowns, repair failures and others, are especially challenging for mathematicians and engineers building a master production plan under imperfect information conditions.

From an economic perspective, the problem has a fundamental importance due to the repercussions in terms of expenditures. A large number of industrially developed countries make great efforts to optimize their energy production and distribution systems through a highly competitive market due to the existence of a multiplicity of public and private companies that are dedicated in this area. It is well known that proper planning of the production and distribution of electricity can result in millions of dollars in benefits to companies that use modern optimization techniques for decision making in their respective companies.

For years, the mathematical optimization of processes has been a fundamental tool in the construction of adequate decisions for real and large-scale problems, immersed in an environment with little or no information on which to base oneself. The development of technology and the growing demand for products and services make it necessary to look for better methods to produce techniques and processes which are profitable and sustainable. In particular, the production and distribution of electricity is a field of opportunity for the development of models and modern optimization techniques capable of solving stochastic instances in an environment with little information, dynamic by nature and characteristically very large due to the great number of variables involved, restrictions and requirements for convergence and precision in reasonable times in their implementation into real systems. The use of exhaustive search algorithms does not give an exact solution and if the search space is very wide, the necessary calculation time can be unapproachable (combinatorial explosion) belying its usefulness.

Today, metaheuristics using random optimization, local search, iterated local search, grey wolves, voracious algorithms, acceptance by thresholds, ascent of hills with random reinitialization, simulated annealing, optimization based on ant colonies, swarm algorithms, taboo search, genetic algorithms, memetic algorithms, GRASP, search by stochastic broadcast, extreme optimization, and penguins search optimization are methods that support the exact methods developed in the past in order to provide practical solutions in time and form with a fairly reasonable accuracy and a speed of convergence useful for making decisions in real contexts.

Associated with the optimization of the operation of the model is also the minimization of the volume of particles emitted to the environment as a consequence of the operation of the thermoelectric plants. Notwithstanding the economic and mathematical importance of the problem addressed, in this analysis we are also interested in estimating and minimizing the volume of pollutant particles emitted into the atmosphere as a consequence of the operation of a group of thermoelectric plants associated with the system. To do this, we make an approximation to the state of the art in terms of mathematical models associated with the production of polluting particles emitted during the process of generating electrical energy in a thermoelectric system in order to incorporate such models into the general structure of the optimization model proposed here. For the above mentioned, we also focus our analysis on estimating and optimizing, through an indirect method, the quantity of polluting particles emitted into the atmosphere as a consequence of the operation of thermoelectric power plants.