Chapter 4
Solving Environmental/Economic Dispatch Problem: The Use of Multiobjective Particle Swarm Optimization

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ABSTRACT

Multiobjective particle swarm optimization (MOPSO) technique for environmental/economic dispatch (EED) problem is proposed and presented in this work. The proposed MOPSO technique evolves a multiobjective version of PSO by proposing redefinition of global best and local best individuals in multiobjective optimization domain. The proposed MOPSO technique has been implemented to solve the EED problem with competing and non-commensurable cost and emission objectives. Several optimization runs of the proposed approach have been carried out on a standard test system. The results demonstrate the capabilities of the proposed MOPSO technique to generate a set of well-distributed Pareto-optimal solutions in one single run. The comparison with the different reported techniques demonstrates the superiority of the proposed MOPSO in terms of the diversity of the Pareto optimal solutions obtained. In addition, a quality measure to Pareto optimal solutions has been implemented where the results confirm the potential of the proposed MOPSO technique to solve the multiobjective EED problem and produce high quality nondominated solutions.

1. INTRODUCTION

Generally, the basic objective of the traditional economic dispatch (ED) of electric power generation is to schedule the committed generating unit outputs so as to meet the load demand at minimum operating cost while satisfying all generator and system equality and inequality constraints. This makes the ED problem a large-scale highly constrained nonlinear optimization problem.

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However, thermal power plants are major causes of atmospheric pollution because of the high concentration of pollutants they cause such as sulphur oxides $\text{SO}_x$ and nitrogen oxides $\text{NO}_x$. Nowadays, the pollution minimization problem has attracted a lot of attention due to the public demand for clean air. In addition, the increasing public awareness of the environmental protection and the passage of the U.S. Clean Air Act Amendments of 1990 have forced the power utilities to modify their design or operational strategies to reduce pollution and atmospheric emissions of the thermal power plants (El-Keib et al., 1994; Helsin et al., 1989; Talaq et al., 1994).

Several strategies to reduce the atmospheric emissions have been proposed and discussed in the literature (Talaq et al., 1994). These include

- Installation of pollutant cleaning equipment such as gas scrubbers and electrostatic precipitators;
- Switching to low emission fuels;
- Replacement of the aged fuel-burners and generator units with cleaner and more efficient ones;
- Considering pollution minimization along with cost minimization of economic dispatch problem. This leads to bi-objective environmental/economic dispatch (EED) problem.

The first three options require installation of new equipment and/or modification of the existing ones that involve considerable capital outlay and, hence, they can be considered as long-term options. The emission dispatching option is an attractive short-term alternative in which the emission in addition to the fuel cost objective is to be minimized. In recent years, this option has received much attention (Chang et al., 1995; Dhillon et al., 1993; Farag et al., 1995; Granelli et al., 1992) since it requires only small modification of the basic economic dispatch to include emissions. Thus, the power dispatch problem can be handled as a multiobjective optimization problem with non-commensurable and contradictory objectives since the optimum solution of the economic power dispatch problem is not environmentally the best solution.

Several techniques to handle the environmental/economic dispatch (EED) problem have been reported. Generally speaking, there are three approaches to solve EED problem. The first approach treats the emission as a constraint with a permissible limit (Granelli et al., 1992). This formulation, however, has a severe difficulty in getting the trade-off relations between cost and emission.

The second approach treats the emission as another objective in addition to usual cost objective (Chang et al., 1995; Dhillon et al., 1993; Farag et al., 1995; Granelli et al., 1992; Yokoyama et al., 1988). However, the EED problem was converted to a single objective problem either by linear combination of both objectives or by considering one objective at a time for optimization. Unfortunately, this approach requires multiple runs as many times as the number of desired Pareto-optimal solutions and tends to find weakly nondominated solutions.

The third approach handles both fuel cost and emission simultaneously as competing objectives. Stochastic search and fuzzy-based multiobjective optimization techniques have been proposed for the EED problem (Das et al., 1998; Huang et al., 1997; Srinivasan et al., 1994). However, the algorithms do not provide a systematic framework for directing the search towards Pareto-optimal front and the extension of these techniques to include more objectives is a very involved question. In addition, these techniques are computationally involved and time-consuming. Genetic algorithm-based multiobjective techniques have been presented in (Abido, 2003; Abido, 2006; King et al., 2006) where multiple nondominated solutions can be obtained in a single run. However, genetic algorithm-based techniques
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