AN ECONOMIC DISPATCH ALGORITHM OF COMBINED CYCLE UNITS

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This paper presents a method to solve the economic dispatch (ED) problem for thermal unit system involving combined cycle units. ED is defined as finding an optimal distribution of system load to the generators in order to minimize the total generation cost while satisfying the total demand and generating capacity constraints. Cost curves of conventional thermal units can be modeled as convex functions and, traditionally, the cost function of each generator is approximated by a single quadratic function. The classic ED problem can be described as an optimization (minimization) problem:

$$\begin{aligned} &\text{minimize:} && \sum_{i=1}^{N} F_i(P_i) = \sum_{i=1}^{N} \left(\alpha_i + \beta_i P_i + \gamma_i P_i^2\right) \\ &\text{subject to:} && \sum_{i=1}^{N} P_i = P_D; \quad P_{i\,\min} \le P_i \le P_{i\,\max}, \quad \forall i = 1, ..., N \end{aligned}$$

where $F_i(P_i)$ is the fuel cost function of the i-th unit, P_i is the power generated by the i-th unit, P_D is the system load demand, $P_{i\,\min}$ and $P_{i\,\max}$ are the minimum and maximum power outputs of the i-th unit and N is the number of units.

Combined cycle (CC) units utilize both combustion turbines (CTs) and HRSG/steam turbines (STs) to produce electrical energy. The different combinations of CTs and STs in a CC unit produce multiple configurations or states. Each state has its own unique cost curve. But there is another more serious problem: the cost curve is not convex. So, ED becomes a non-convex optimization problem, which is difficult, even impossible to solve by conventional methods. As a result, ED of CC units must use special techniques. Some of these techniques are: Enumeration/Iteration, Dynamic programming, Sequential unconstrained minimization technique, and Heuristic optimization methods: Genetic Algorithm (GA), Evolutionary Programming (EP), and Particle Swarm (PS). Although these heuristic methods do not always guarantee obtaining the globally optimal solution, the numerical results show that, in general, these techniques are capable of providing approximate global optimal solution for non-convex optimization problem.

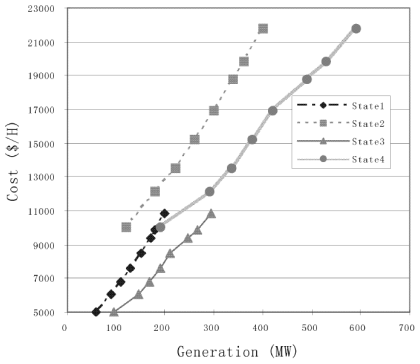

Figure 1. Picewise Linear Cost Curves of a CC unit.

In this paper we present a new technique for solving the ED problem of CC units. The technique, developed to find the global solution, is based on the calculation of the Infimal Convolution and the function merger. The proposed recursive algorithm for calculating the analytic solution consists of two phases: the calculation of the infimal convolution of 2 piecewise linear functions and the calculation of the minimum of a set of linear functions (the function merger). Finally the proposed method is applied to a test ED problem and our solution is compared with three stochastic optimization techniques: GA, EP and PS.