Chapter 1
Introduction

1.1 Introduction

Economic dispatch (ED) is used to determine the optimal schedule of on-line generating outputs so as to meet the load demand at the minimum operating cost under various system and generator operational constraints. In Thailand, the existing ED program, a standard function of the Energy Management System (EMS), National Control Center (NCC), the Electricity Generating Authority of Thailand (EGAT), is applicable only for monotonically increasing incremental cost (IC) functions which is limited in flexibility. Neither linear decreasing IC functions nor staircase IC functions can be handled by the program [1].

Liang et al. proposed the zoom dynamic programming (ZDP) method to solve economic dispatch with transmission line losses on the 15 thermal generating unit system [2]. Even though the zoom feature could speed up the convergence rate with a small memory requirement, it was expected that the computing time would increase enormously as the system size was larger which might not be practical for implementation.

Sheble et al. presented the use of refined genetic algorithm (RGA) to solve ED problems with valve point loading generator cost functions [3]. Several techniques were explored to enhance the efficiency and accuracy such as mutation prediction, elitism, interval approximation, and penalty factors. Satisfactory test results however were shown on a very small size three-bus system.

Wong et al. proposed a simulated annealing based economic dispatch algorithm [4]. The dispatch results obtained for the test system were more economical than those found by the ZDP technique. However, the proposed SA was tested on the system consisting of three generating units only. Subsequently, the genetic and genetic/simulated annealing approaches were proposed to determine the optimal or near optimum solution of the economic dispatch problem [5]. The algorithms demonstrated a higher quality of solution and faster computational speed than the earlier SA method on the 13 generating unit system.

Ongsakul presented a merit order loading (MOL) method to solve the real time economic dispatch (ED) problem with linear decreasing and decreasing staircase incremental cost (IC) functions for combined cycle (CC) generating units [6]. The real-time ED based on MOL method can be easily implemented in the control center to obtain a reasonable good solution. Subsequently, the micro genetic algorithm based on migration and merit order loading solutions (MGAM-MOL) for solving the constrained economic dispatch with linear decreasing IC and decreasing staircase IC functions is proposed [7]. MGAM-MOL used a merit order loading (MOL) solution as a base solution to reduce the search effort to the optimal solution. The MGAM-MOL solutions were less expensive than those obtained from simple genetic algorithm (SGA), micro genetic algorithm (MGA), and MOL.

Meanwhile, Ongsakul et al. proposed the genetic algorithm based on simulated annealing solutions (GA-SA) algorithm to solve the constrained dynamic economic dispatch problem [8]. The GA-SA was tested on the generating unit systems with non-monotonically and monotonically increasing IC functions. The GA-SA solution was superior to those of GA and SA alone in terms of the quality of solutions.

In this thesis, a combined genetic and simulated annealing algorithm (CGSA) is proposed to solve ramp rate constrained ED problem for generating units with non-monotonically and monotonically increasing IC functions. As the transmission line losses are incorporated, CGSA is tested on the 10 generating unit system and compared to the zoom brute force (ZBF), ZDP, local search (LS), SA, GA, GA based on SA solutions (GA-SA), and merit order loading (MOL) methods. To illustrate the quality of CGSA solutions on larger generating unit systems, the algorithm is also tested and compared to the others on the 20, 40 and 80 generating unit systems.

Four types of cost functions for combine cycle (CC) and thermal generating units obtained from the EGAT are used as the test data as follows [1]:

- The second order polynomial cost function of a thermal unit, $C_i(P_i) = a_i + b_iP_i + c_iP_i^2$ and its linear increasing IC function, $IC_i(P_i)=b_i+ 2c_iP_i,\ c_i > 0$.
- The second order polynomial cost function of a CC unit, $C_i(P_i) = a_i + b_iP_i + c_iP_i^2$ and its linear decreasing IC function, $IC_i(P_i)=b_i+2c_iP_i,\ c_i < 0$.
- The piecewise linear cost function of either thermal unit or CC unit and its increasing staircase IC functions are

$$C_i(P_i) = a_{i1} + b_{i1}P_i,\ P_{i,min} \leq P_i < P_{i,int} \tag{1a}$$

$$= a_{i2} + b_{i2}P_i,\ P_{i,int} \leq P_i \leq P_{i,max} \tag{1b}$$

$$IC_i(P_i) = b_{i1},\ P_{i,min} \leq P_i < P_{i,int} \tag{2a}$$

$$= b_{i2},\ P_{i,int} \leq P_i \leq P_{i,max} \tag{2b}$$

where $b_{i2} > b_{i1}$.

- The piecewise linear cost function of a CC unit and its decreasing staircase IC function is the same as Equations (1) and (2) except that $b_{i1} > b_{i2}$.

1.2 Outline of thesis

The organization of this thesis is as follows: Chapter 2 describes the constrained ED problem formulation. Chapter 3 proposes the combined genetic and simulated annealing algorithm (CGSA) whereas zoom brute force (ZBF), zoom dynamic programming (ZDP), simulated annealing (SA), local search (LS), genetic algorithm (GA), genetic algorithm based on simulated annealing solution (GA-SA), and merit order loading (MOL) are developed for comparison. Chapter 4 provides the test data, parameter selection, and experimental results on the number of generating unit systems in the range of 10 to 80. The solutions of ZBF, ZDP, SA, LS, GA, GA-SA, and MOL are compared to those of CGSA. Lastly, conclusion and future work is given.