CHAPTER II

REVIEW OF OPTIMIZATION

2.1 General Concept of Optimization

Optimization is an important tool in the field of process synthesis. Reflecting its significance, many works had been published in the technical literature.

Many an optimization textbook has been written on the theory and applications of linear programming, of which the simplex algorithm is very efficient and relatively simple in concept and use.

To optimize a chemical process, we usually encounter a nonlinear programming problem containing numerous nonlinear equality and inequality constraints. Various methods and approaches have been developed to solve the optimization problem. One typical approach is to use local linearization and the simplex algorithm to find the optimum of the linearized problem. Various troubles generally arise if the objective function and/or constraints are highly nonlinear or the feasible domain is very wide. Another approach is to recast the problem into an unconstrained nonlinear problem and apply certain appropriate penalty functions to penalize the objective function whenever a constraint is about to be or being violated. A third approach requires the optimization algorithm itself to detect any constraint violations and to project the search direction back into the feasible region. For example, the method of Lagrange multipliers and random search technique might be used.

2.2 Past work of Chemical Process Optimization

If we direct our attention to solving optimization problem, we generally have to come up with a model of the process before selecting a suitable optimization such as the random search technique, the multiplier method, the successive quadratic programming (SOP), etc. These methods have been developed and modified to tackle relatively complicated chemical processes. In 1963 S.A. Hovanessian and T.M Stout [11], made certain generalization of the simplex method of linear programming and applied it to cerpain types of nonlinear problems, such as Optimum Fuel Allocation in Power Plant. At about the same time D.M. Himmelbau [2] applied the adaptive search technique to optimize a butane isomerization process. In the latter case, the objective function itself may be linear, nonlinear or expressed as some integral.

R.N. Sauer [3] developed a computer program to optimize an alkylation process [4] but his method was still based on the linearization of the problem, as C.W. Dibella [5] had done with William and Otto's process.

T. Umeda [6] applied the complex method to the optimal design of an absorber-stripper system. This complex method is a type of search methods.

In 1970 the penalty functions was first introduced to optimize a C8 Isomer Separation Process [7]. In fact the 1970's decade seemed to be era of the "modified complex method" and the "random search" technique. for example, the modified complex method [8] was used to optimize Rosenbrock's parabolic valley problem, an isothermal reactor, and the design of an absorber-stripper system. The method have also been used to solve such classical optimization problem as William and Otto's process [9] and the polymerization of olefin [10].

Later Luss and Jackola [11] introduced the use of elementary calculus and the random number to solve several examples of optimization problems. The method subsequently leaded to the adaptive random search technique [12], which chooses new search points in the vicinity of the best previously known objective function. R. Goulcher [13] used a randoms search algorithm to solve 13 steady-state chemical engineering optimization problems.

After 1980, the published work in the field of optimization turned the attention to making comparative studies of different optimization algorithms [14]. The method of geometric programming [15] and the multiplier methods [16], [17] were studied quite extensively.

S.A. Papoulias [18] applied a mixed-integer linear programming approach to performing structural and parameter optimization in the synthesis of process systems.

2.3 Past work of Chemical Process Optimization using GRG

The GRG (generalized reduced gradient) method had successfully been applied to the optimization of an electrolytic cell [19] and of a monochlorobenxene production process. It had also been show that GRG algorithms could be applied to large-scale nonlinear programming [21].

It was our challenge to use the GRG method to optimize a real-life cogeneration problem.

Admittedly there is no "universal" or "almighty" optimization method that can solve every and each type of optimization problems. Nevertheless, it would be wise to choose a "robust" optimization method, such as the GRG method, rather than a very fast but failure-prone method.

In the cogeneration problem, the objective function to be minimize is the total "net" energy producting costs and the governing equality constraints are the heat and mass balances and the inequality constraints are mostly require to ensure that such variables as flow rates must vary within acceptable ranges, and so on. The formulation and optimization of the problem will be discussed in subsequent chapters.