CHAPTER I

INTRODUCTION

1.1 Importance and Reason of Research

Optimization is the use of specific methods to identify the most cost-effective and/or efficient solution to a problem or design for a process (Edgar, Himmelblau, and Lasdon, 2001). Optimization is one of the major quantitative tools in industrial decision making because it is able to enhance performance and to reduce operating cost of unit operations or processes. Traditional optimization methods also known as calculus-based methods, such as gradient descent methods, quasi-Newton methods, and SQP methods, are commonly used to solve optimization problems, because they can easily solve and quickly convert to the optimum point. Unfortunately, in real world optimization problems, complex optimization problems, traditional methods usually fail to provide reliable solutions (Grossmann and Biegler, 2004). One key difficulty lies on the fact that complex optimization problems usually have a great numbers of local optima. Thus, solutions resulting from traditional methods are easily trapped into a local optimum. Moreover, calculus-based methods depend upon the existence of derivatives (well-defined slope values). Therefore, discrete variables usually faced in real world optimization problems cannot be efficiently handled without special treatment. Then, probabilistic-based algorithms have been developed to overcome these difficulties.

Genetic algorithm (GA) is one of the probabilistic-based approaches based on the idea of evolution and survival of the individuals with high fitness. This algorithm starts generating a random population, and then repetitively evolving it with three basic genetic operators: selection, crossover, and mutation. This approach can successfully solve complex optimization problems because GA has several advantages. For example, GA can optimize with continuous and discrete variables, GA does not require derivative information, and GA simultaneously searches from several points, not a single point. However, GA has some major shortcomings: premature convergence, and weak exploitation capabilities (Chelouah & Siarry, 2000). Occurrence of premature convergence makes GA stop at a local optimum, not a global optimum, while weak exploitation capabilities often cause slow convergence of GA. These drawbacks lead GA to fail to obtain reliable solutions.

In order to find the most acceptable solution, a new efficient genetic-based optimization algorithm has been developed in this research. According to Haupt (2004), the good initial population plays an important role in searching the global optimum. Therefore, several sampling strategies: Latin Hypercube Sampling (LHS), Faure Sequence Sampling (FSS), and Hammersley Sequence Sampling (HSS) have been introduced to select the good set of initial population. In order to compare the performance of these improved algorithms with simple genetic algorithm (SGA), several optimization problems have been used as test problems. Our algorithms are then applied to the optimization problem of distillation sequence synthesis.

1.2 Objectives of Research

The objectives of our research are to improve insights of genetic algorithm (GA) including their genetic parameters: selection, crossover, and mutation. GA is then developed in order to overcome its drawbacks: premature convergence and weak exploitation capabilities in solving complex optimization problems. Finally, the proposed algorithms are applied to the problem of distillation sequence synthesis.

1.3 Scopes of Research

Our research focuses on the development of genetic algorithm with sampling techniques: Latin Hypercube Sampling (LHS), Faure Sequence Sampling (FSS), and Hammersley Sequence Sampling (HSS), for solving complex optimization problems. The performance of these algorithms is tested on several problems, and then, the proposed algorithms are applied to the problem of distillation sequence synthesis.

1.4 Contributions of Research

This research provides newly developed algorithms being able to reduce computational time and/or to provide reasonable solutions. This algorithm can also be applied to chemical engineering optimization problems. Moreover, the work gives a new way to enhance the performance of GA or other probabilistic-based approaches depending on random initial population.

1.5 Structure of Thesis

The thesis can be divided into six chapters. In the first chapter, "Introduction", we discuss importance and reasons of this thesis. The objectives and scopes of this work are also clarified.

Chapter II, "Genetic algorithm", describes the theory of Genetic algorithm (GA). The principle steps of GA, such as selection, crossover, and mutation step are explained. Moreover, the example of solving GA by hand is demonstrated. Various advantages and applications of GA are also presented at the end of this chapter.

Chapter III, "The improvement of GA performance", highlights the technique to improve the performance of GA. We review strategies to improve, and propose sampling techniques to develop GA performance for this work. The concept of several sampling techniques is discussed. Moreover, the characteristic of each sampling technique are illustrated.

Chapter IV, "The proposed algorithm", shows our algorithms. Our algorithms are LHS-GA, FSS-GA, and HSS-GA. The performance in terms of solution quality and speed of convergence to the global solution of these algorithms is tested through six optimization problems. The results are then discussed and compared with simple genetic algorithm (SGA).

Chapter V, “Distillation optimization”, presents the application of our algorithms to a chemical engineering optimization problem. The case study is explained consisting of detail of the problem, model formulation, and optimization result. The performance of our algorithm and SGA is then compared. Finally, the results concerning the performance of these algorithms are discussed and summarized.

Chapter VI, “Conclusions and Future prospective”, concludes the thesis by summarizing the main results of each chapter, and discussing the new contributions. Finally, we present the future opportunities relating to this research area, and explain an outlook on possible extensions.