CHAPTER I
INTRODUCTION

Most problems in science and engineering calculations are in the form of differential equations (DE). For example, in mechanical engineering, a temperature profile in an internal combustion engine is calculated by solving differential equations that explain heat conduction. Deformation analysis of materials under pressure due to fluid flow starts with differential equations. Chemical engineers also deal with differential equations to analyze temperature and pressure gradient in fluid flow systems.

Frequently, problems are in the form of "partial differential equation" (PDE), which has more than one independent variable. Mostly, useful PDE in chemical engineering is linear second-order PDE that has a general form of,

$$A\frac{\partial^2 u}{\partial x^2} + B\frac{\partial^2 u}{\partial x \partial y} + C\frac{\partial^2 u}{\partial y^2} + D\frac{\partial u}{\partial x} + E\frac{\partial u}{\partial y} + Fu = G\,, \qquad (1.1)$$

where A, B, C, D, E, F, and G are functions of independent variables x and y, and u is a dependent variable such as temperature in heat conduction problem. For example, heat conduction equation (two dimensions) is expressed by,

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + f - gu = 0\,, \qquad (1.2)$$

where u is temperature, and (f-gu) represents a source or generation term depending on the temperature. This equation is known as Poisson's equation. To solve such DE problems, the equation must be supplemented by boundary conditions, e.g. specified u (Dirichlet condition), $\partial u/\partial n = 0$ (Neumann condition), or mixed conditions.

These DEs are usually solved by: 1) analytical methods for exact solution or 2) numerical methods to find approximate solution. For highly complex problems, the exact solution cannot be easily found. With high performance of computer technology, numerical methods, thus, can be applied with ease.

One of numerical methods is “finite difference method” that can give good approximate results. But it has some important restrictions. Especially, it cannot deal with complicate-boundary problems effectively. For this case, a more effective method, finite element method (FEM), will be applied instead.

The finite element method, in contrast to the finite difference method, provides an alternative that is better suited for systems with irregular geometry, unusual boundary conditions, or heterogeneous composition. It divides the solution domain into simply shaped regions, or “elements”. An approximate solution for the PDE can be developed for each of these elements. The total solution is then generated by linking together, or “assembling”, the individual solutions taking care to ensure continuity at the inter element boundaries. Thus, the PDE is satisfied in a piecewise fashion.

FEM is practically applied for solving various problems in engineering, particularly in heat conduction, fluid flow, and structural analysis etc. The main objective of this work was to develop a computational program with a user-friendly interface to apply FEM to chemical engineering problems. The application program was developed using the Visual Basic. The results from the program were discussed and compared to other available methods.