

Preface

Indoor air pollution is becoming a serious problem. This is especially pertinent in situations where sick building syndrome, under design air flow, and contaminant dispersion occur. Recent interest in homeland security and the aftermath of terrorist activities have created a desire among many governmental agencies to more fully understand interior pollutant dispersion and risk assessment. It is the intention of this book to acquaint the reader with enough information to begin using various modeling tools for assessing indoor air pollution. There are many levels of models, ranging in sophistication from simple analytical expressions to elegant, 3-D schemes for solving the Navier–Stokes equations for fluid flow and species transport. The level of modeling effort resides ultimately with the user, and the desired level of accuracy. While 3-D numerical schemes based on finite difference, finite volume, or finite element techniques provide elegant solutions, they also require a great deal of understanding, patience, and computational resources. Analytical solutions, while fast and simple, may be orders of magnitude off in comparison to actual values. This book presents these most common of numerical and analytical tools that can be used for modeling indoor air pollution and the types of problems where a particular model is best suited.

Chapter 1 presents an overview of indoor air pollution, types of ventilation systems, exposure, and general modeling techniques. Chapter 2 discusses the governing mathematical equations that serve as the basis for modeling air pollutant and flow patterns. In Chapter 3 a general discussion of contaminant sources routinely associated with indoor air quality assessment studies is given, with a presentation on particulates and evaporation of droplets. Assessment criteria are described in Chapter 4, including what to consider in exposure levels as well as economical issues associated with design. Chapter 5 introduces the fundamental analytical tools, along with advection and the classic box model approach, for performing simple model simulation, including their

limitations. The dynamics of particle motion, including particle drag and flow in inlets and flanges, are given in Chapter 6. Chapter 7 describes the fundamental numerical approaches commonly used in CFD-type simulations, which are based on finite difference, finite volume, and finite element techniques. Additional discussions are given in Chapter 8 on more advanced methods that include boundary element, particle-in-cell, and meshless methods, which is relatively new. Several modeling examples are included. In Chapter 9, an extensive description of turbulence modeling is presented with consideration to both finite volume and finite element techniques. A time-dependent, two-equation closure model is presented in detail using the finite element method with adaptive meshing; results are shown for example problems. Issues regarding homeland security and the potential threats attributed to terrorist activities are discussed in Chapter 10, including an example scenario.

The examples and computer techniques discussed in the book are available on the web. The website is: www.iaqcodes.com. We have elected to write the majority of the codes in MATLAB. The website lists locations where you can also find FORTRAN and C/C++ versions of some of the example codes. We have found that most engineering graduates today as well as science and engineering students are familiar with MATLAB, and prefer using it as their primary coding environment. We have also used COMSOL to run the example problems. COMSOL, with headquarters in Sweden, is a very versatile multiphysics finite element package used throughout the world; the package permits easy interface and flexibility in setting up problems, along with MATLAB scripting. Many universities and companies are now using COMSOL. In addition, an adaptive finite-element based model that can be used for indoor air pollution is also available from the authors. This model utilizes h-adaptation (mesh refinement) to accurately simulate the dispersion of contaminant within any shaped interior.

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2008