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★**Finite element analysis for heat transfer. (English summary)**

Theory and software.

With 1 IBM-PC floppy disk (3.5 inch; HD).

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This book presents an introduction to the application of the finite element method to the analysis of heat transfer problems. The discussion is limited to diffusion and convection types of heat transfer in solids and fluids. Without reference to any particular application, this text provides a means to the reader/user enabling him to solve a large number of different heat transfer problems, for example: heat conduction in solids, phase change (solidification and melting) problems, and convective heat transfer.

The main objectives of this book may be listed as follows: (1) Remind the reader of the basic equations that govern the various forms of heat transfer. (2) Explain the background and fundamentals of the finite element method. (3) Describe the general procedure for achieving spatial and temporal discretisation of the governing equations via the finite element method. (4) Introduce special techniques for dealing with phase change problems. (5) Validate the numerical techniques using standard analytical solutions as benchmark tests. (6) Extend the basic FEM approach to include adaptive analysis based on error estimation. (7) Discuss the difficulties encountered when forced convection problems are solved using standard FEM and how they are overcome. (8) Provide a fully documented set of software with the source code to the reader with test examples covering most topics in the text.

The first four chapters include a review of the basic heat transfer concepts, the governing equations, and a gradual introduction to FEM. The last three chapters present special topics: phase change, adaptivity, and convection/advection.

Chapter 2 is devoted to establishing the basic differential equations that govern the different forms of heat transfer and the various boundary conditions that may be applied. Chapter 3 introduces the reader to the mathematical background of the finite element method following which the basic concepts are explained. The spatial discretisation of the governing equations of heat transfer is then demonstrated using the basic principles established earlier. Discretisation in the time domain for transient (time-dependent) problems is discussed in Chapter 4. Various schemes that are normally used in heat transfer analysis are presented. Special numerical techniques used for solving phase change problems are described in Chapter 5. These techniques are evaluated by comparing them with available analytical solutions for freezing and melting.

To obtain an accurate solution, it is sometimes necessary to use very fine meshes in regions of a problem domain where high gradients of the field variable exist. The variation of field variable in the rest of the domain may, on the contrary, be so gentle as to require a very coarse mesh for its adequate resolution. The areas of high gradient may not always be predictable and in the case of transient problems, they may not be restricted to a particular region. Therefore, if a fixed fine mesh is used in solving such problems, it may turn out to be unacceptably expensive. For such problems, the technique of adaptive analysis based on estimating the discretisation error provides an economical alternative. This technique is developed for heat transfer problems in Chapter 6.

In the analysis of heat transfer problems where convection is the dominant mode of transport, the conventional Galerkin form of the finite element method proves to be inadequate. Several techniques are used to modify the conventional method to model the convection dominated heat transfer problems successfully. Some of these techniques are discussed in Chapter 7.

Finally, two appendices give complete details of the programs HEAT2D and HADAPT, with full user instructions and documented examples. HEAT2D is a program capable of steady and transient, linear and non-linear analyses of diffusive and convective heat transfer. HADAPT is an adaptive version of HEAT2D and includes subroutines for error estimation and unstructured mesh generation of triangular and quadrilateral elements in arbitrary geometries. The complete source code for both the programs and sample input data files is provided on a floppy disc included with the book.

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