Book Review

G. Höhne, W. Hemminger, H.-J. Flemmersheim:
Differential Scanning Calorimetry
Ab Introduction for Practitioners
ISBN 3.540–59012–9 Springer-Verlag, Berlin, Heidelberg, New York, 1996

This book describes differential scanning calorimetry as a tool for instrumental analysis and as a thermoanalytical method.

The purpose of the authors is revealed by the substitute, the book being intended for practitioners rather than beginners. The Preface provides definitions of both the DSC and DTA methods according to the ICTAC, to avoid any overlapping with the classical calorimetric methods.

The authors, who are experts in this field, point out current problems, including, for example, the calibration. They focus on crucial circumstances which sometimes make the interpretation of DSC curves insufficient of incorrect.

In the first two chapters, the authors present a detailed survey of the types of differential scanning calorimeters and the theoretical fundamentals of DSC apparatus. The second chapter also discusses how the shapes of DSC curves are influenced by the heating rate, the heat of transition measured, and the heat conduction properties of the sample.

One of the main topics of the book is the calibration of the DSC cell (Chapter 4). The importance of the procedure is stressed, with an account of the different possibilities, and an evaluation of the advantages and disadvantages of the different methods.

The authors detail a large set of substances which can be used for temperature, heat flux rate and peak area calibration. They point to the lack of an international agreement on DSC temperature and caloric calibration definitively supported both theoretically and experimentally.

Chapter 5 relates to questions of DSC curves, the parameters influencing them and the problem of the baseline.

The practising thermoanalyst does not have to wait too long for a discussion of the applicability of the method. This part of the comprises about 1/3 of the total volume, and furnishes almost all of the possibilities, together with practical considerations. The final chapter presents an evaluation of the performance of DSC.

Overall, the principles and applications of DSC are clearly described, and a realistic picture of the current status is provided, with both advantages and disadvantages. This is a book that is well worth reading.

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R. W. Lewis, K. Morgan, H. R. Thomas, K. N. Seetharamu: 'The Finite Element Method in Heat Transfer Analysis', John Wiley & Sons, Chichester, New York, Brisbane, Toronto, Singapore, 1996, ISBN 0 471 93424 0; 0 471 94362 2 pp: X+279

The techniques of numerical calculation of heat transfer (NCHT) finds application in diverse branches of engineering and science. These calculations are essential in chemical engineering (thermal unit operations), mechanical engineering (thermal stresses), civil engineering aeronautic engineering, electrical engineering (heat accumulation and removal, for example), etc., including both steady-state and transient problems. All these involve the numerical solution of two and three-dimensional boundary value problems described by linear differential equations, sometimes coupled with differential equations of different forms (for example, the differential equations of fluid flow), and usually with non-constant coefficients because of the usual non-homogeneity of the material properties in space, and transient problems as well. One possible and effective way of performing numerical calculations is to apply the finite element method (FEM).

Numerous books have been published on the theory and application of both FEM and NCHT. Although the application of FEM for NCHT is usually mentioned, and even demonstrated, in FEM texts, and sometimes in NCHT texts as well, and the topic is at the centre of a huge number of scientific and technical journal articles, no such detailed theoretical and technical introductional text has been published before on this specific topic. The structure and the content of this book reveal that. The intention of the authors was to introduce the reader to both the theory and the practical application of this method, and to explain, through numerical examples, what particular techniques and tricks are to be preferred in important specific technical problems. This approach can be discerned throughout the book.

The text is divided into seven chapters, followed by a detailed Nomenclature, and then Index. Each chapter is subdivided into subchapters, the first of which is a very short introduction. Subchapters outlining theoretical or technical material are usually followed by a subchapter demonstrating numerical examples. Each of the first two, theoretical, chapters is ended by a list of recommended additional reading; and the other chapters are ended by a list of references.

The first three chapters are devoted to the elements of FEM. Through the problem of heat conduction (derivation of the governing equations, and the initial and boundary conditions), the authors give a brief introduction to the variational formulation, and the Galerkin approximation is derived from the weak variational formulation. Other weighted residual methods are not mentioned. The finite elements themselves are shown in minimal abundance, the shape functions being well illustrated in figures. The use of the different kinds of final elements in one and two dimensions is then further explained and demonstrated in the context of heat conduction problems with constant parameters. Numerical integration is explained; the techniques relating to the solution of large but sparse systems of linear equations, generated during the FEM method, are not touched on. Instead, the formulation itself is at the focus. The time evolution problems are dealt with in Chapter 3. After a short introduction to the initial value problems, the different kinds of time discretization are discussed and the stability of FEM and the finite differences methods are then compared.

Chapter 4 discusses the techniques of solving heat conduction problems with non-constant coefficients, special-shaped objects, and objects assembled from parts of different materials. This includes detailed demonstration calculations and well-elaborated examples, with numerical tables, graphs, and even the figure of the final element mesh with arrangement and numbering. This detailed presentation of the numerical examples is characteristic of all the chapters.

The next chapter includes explanations and examples on how to calculate phase change processes (melting and solidification) where the phase boundary is displaced in time. The elaborated examples include ingot casting, ingot casting with moulding, continuous casting, and aluminium casting. Other uses, such as protection boxes against fire hazard, and squeeze forming, are also mentioned.

Coupling heat transfer with fluid flow essentially increases the complexity of the problem to be solved, and this is common in practice (natural convection develops almost everywhere, combustion chambers, heat exchangers, etc.). This is the topic of Chapter 6. Upwind methods, the Taylor-Galerkin method for transient convection-diffusion problems, and *v–p–T* formulation are explained. Elaborated examples are provided for heat transfer in a fluid flowing between parallel planes. The effects of convection on melting and solidification, and mould filling in castings are demonstrated.

Three additional, perhaps more complex, problems are considered in the last chapter, Chapter 7: the development of thermal stresses arising out of non-uniform temperature distribution in a material, coupled heat and moisture movement in a capillary porous material, and shrinkage stress development heat and moisture movement in a capillary porous material, and shrinkage stress development arising out of non-uniform moisture content distributions in a drying material. These are dealt with via the same approach as in the preceding chapters: derivation of the basic equations of the process itself, application of the finite elements, and elaborated examples including finite element mesh maps and numerical details. However, these examples are a little less detailed, and more demonstrative.

Throughout the text, one can feel the didactic experience of the authors. Although this small volume cannot aspire to be regarded as a university textbook, and, of course, problems and check questions are not provided, the reader can readily learn the theory and practise solving the examples, and even check the results. In consequence of the structure, this text could form the basis of a PhD course for engineering or science (physics or chemistry, but not mathematics) students. On the other hand, this book is more than a didactic introduction, since the reader can find the diverse branching of potential applications and the most essential literature references.

I can suggest this book to everyone interested in the numerical simulation of heat and mass transfer.

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