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BOOK REVIEW

The Finite Element Method in Heat-transfer Analysis, by R. W. LEWIS, K. MORGAN, H. R. THOMAS and K. N. SEETHARAMU, John Wiley, 1996

Is this book intended for:

(1) those who know much about heat transfer, but little about the finite-element method?
(2) those who know about finite elements, but not about heat transfer?
(3) those who know little about either?
(4) some other defined group of readers? or
(5) none of the above, because the authors have not asked themselves the question.

This reviewer belongs to group 1, and can testify that the book cannot be intended for his group because it fails to define emphatically and unambiguously such crucial terms as: 'strong' and 'weak' formulations; 'stiffness matrix'; 'Galerkin method'; 'essential' and 'natural' boundary conditions; and numerous others.

These topics are indeed introduced, but in such a roundabout manner that the newcomer does not know whether he has just been given one of the main building bricks of the theory, or merely been subjected to a preliminary 'get-accustomed-to-the-jargon' session, which will be followed by a 'firm-information' session later. This may not matter for group 2 readers, for whom the text serves simply as a reminder of what they already know; but it sadly saps the confidence of the newcomer.

For example, one of the few things which I know about the Galerkin method is that the weighting functions are chosen to be the same as the interpolation functions. Yet, so far as I could see, this important piece of information is not stated explicitly until p. 172, even though the method is first introduced on p. 13. Perhaps the information could be deduced from that early section by an extremely percipient between-the-lines reader, but certainly not by me.

Not being for group 1, the book cannot logically suit group 3 either. What about group 2?

If the book is for them, this reviewer is of the opinion that they deserve a rather more extensive introduction to heat transfer than the two-and-a-half pages in Chapter 2 on conduction, and the two-thirds of a page in Chapter 6 on convection. Space for this could have been saved by condensing the introduction of the standard finite-element topics alluded to above, which does not, as has just been stated, satisfy the needs of the beginner.

There is a further deficiency: group 2 readers do not need to be convinced of the merits of finite-element methods in general; but they do need to be warned, when they are invited to apply their knowledge to heat-transfer analysis, that other methods already exist and are found to be satisfactory by their users; and they would be helped by an appraisal of the classes of problems, if any, for which the finite-element method is at least as good, in some of the various meanings of that word, as the other methods.

All that they are told by the present authors is: "The finite-element method, with its flexibility in dealing with complex geometries, is an ideal approach to use in the solution of such problems." It is not enough, I suggest, to protect them from disappointment.

If the book is intended for group 4, one would expect the identity of that group to be defined in the preface. It is not. Indeed, perhaps revealingly, readers are not mentioned there at all. "We decided to write this text", the authors state there, because of the flourishing of "our joint research work ... ".

They continue as follows: "The need for this book stems from the fact that few texts of this kind exist." By such an argument one could justify the opening of an ice-cream kiosk at the North Pole! From this and many other instances your reviewer has concluded that the four authors collectively have not taken care to check, and to correct when necessary, the absurdities which one of them has written.

Anyway, what is meant by "few texts of this kind"? I have found the book by D. W. Pepper and J. C. Heinrich [*The Finite Element Method.* Hemisphere (1992)], which pays much attention to heat conduction, to be very informative; the articles on a wide variety of finite-element methods in the *Handbook of Numerical Heat Transfer* [Edited by Minkowycz, Sparrow, Schneider and Pletcher. Hemisphere (1988)] have taught me much; and I have caught sight, from time to time, of a considerable number of substantial-seeming textbooks.

It therefore seems that the answer to the question posed at the start of this review is: group 5.

However, even ill-focused books can convey some useful information. This one reveals that the finite-element method, despite its inherent (as some may think) clumsiness, has actually been used by the authors or their associates for the computer simulation of:

- simultaneous heat and moisture transfer;
- thermal-stress development;
- continuous casting;
- shrinkage; and
- associated plastic and visco-elastic behaviour.

This is interesting; and, for those who use rival methods, it is challenging. The question in this reviewer's mind was therefore: how were the specific features of these processes formulated? Here is one of the explanations:

"The visco-elastic behaviour of timber during drying is analysed by means of an approach proposed by Srinatha [4] whereby temperature and content influence on viscoelasticity is described by a time-dependent and moisture content equivalence hypothesis. In a thermoviscoelastic problem, for example, the appearance of temperature as a variable is removed by shifting the real time based on a time–temperature equivalence hypothesis [31]. This approach is extended for a drying problem to include both time–temperature and time–moisture content equivalence."

It appears from this tangled paragraph that all parts of the timber are required to have the same temperature and the same moisture content at any instance of time, a condition which is not less restrictive for being called "thermohygrorheologically simple". Simple certainly; for the heat- and mass-transfer aspects are thereby entirely removed!

What is also interesting to note about the further development of the analysis is that, despite the "flexibility in dealing with complex geometries" claimed above, no attempt is made to exploit that flexibility by fitting the grid on the one hand to the concentric-circle shapes of the timber grain and on the other to the rectangular boundaries of the plank.

These observations evoke again the question: 'granted that the FE method *can* be used, albeit with severe simplifications, to simulate processes of this kind, what reason is there to believe that is the *best* way of so doing?' No answer will be found in this book.

Sometimes authors who have difficulty in expressing their ideas in plain text succeed nevertheless in making their techniques accessible to their readers by supplying computer-program listings, or even floppy diskettes. The present authors do not do so.

I hope that this review will not be treated as an attack on the finite-element method, about which I truly sought enlightenment; nor indeed on the authors, whom I much respect. But there are four of them; and all are busy persons. I suspect that they were content to put together, with slight modification, such writings as they had already completed for other purposes, and that they did not thereafter form themselves into an editorial committee, so that each could scrutinize critically what his colleagues had written. Had they done so, their book, and this review also, might have been much more agreeable to read.

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