Rezensionen

Blekhman, I. (editor):
Selected Topics in Vibrational Mechanics
World Scientific, 2004
ISBN 981-238-055-8, € 114

Vibrational Mechanics is a young and fast-growing branch of nonlinear dynamics with applications not only in technology (e.g. building new vibrating machines, processing granular materials, eliminating harmful vibrations, selfbalancing) but also in celestial mechanics, physics, chemistry, biology, physiology, medicine even economics and sociology. The ideas underlying the vibrational mechanics were introduced for the first time by Professor Blekhman in 1973.
Vibrational Mechanics is a mechanics of the slow motion at the action of vibration on nonlinear mechanical systems, i. e. mechanics for observer who does not notice the fast motions and fast forces.
Professor Blekhman's work has evoked much interest in the US, Japan, Denmark, Germany, Bulgaria, Iran, Russia, and Canada because of its potential applications and theoretical implications. It has also served as an inspiration for many other researchers. The present volume contains contributions from his collaborators in Russia, Denmark, and Germany.
The book "Selected Topics in Vibrational Mechanics" represents an excellent contribution to the literature on nonlinear dynamics and oscillation theory. It will be of great interest to all those physicists, mathematicians, engineers, and of course to specialists in the science of mechanics who sooner or later will deal with such phenomena.

A. Guran

Hetnarski, R.B.; Ignaczak, J.:
Mathematical Theory of Elasticity
Taylor & Francis, New York 2004, 821 p.
ISBN 1-59169-020-X, USD 134,95, € 124,90

The theory of elasticity is one of the oldest branches of mechanics. The history starts with Galilei, many contributions were made by such famous scientists like Bernoulli, Hooke, Euler, Cauchy, Kirchhoff, among others. The history till 1950 was reported by Todhunter and Pearson (A History of the Theory of Elasticity) and Timoshenko (History of Strength of Materials). The book of Hetnarski and Ignaczak contains some additional historical remarks concerning the developments in Elasticity of the last fifty years.

The aim of the book is to present the Mathematical Theory of Elasticity and its applications in a form suitable for a wide range of readers including graduate students, phd students, and those concluding research in continuum mechanics. There are only a few textbooks at this level, for example, A.I. Lurie's Nonlinear Theory of Elasticity (1970 in Russian, 1990 in English) or H.G. Hahn's Elastizitätstheorie (1985 in German) giving an excellent overview, but now Taylor & Francis presents such a book in English.

The textbook is divided into 13 chapters: creators of the theory of elasticity, mathematical preliminaries, fundamentals of linear elasticity, formulation of problems of elasticity, variational formulation of elastostatics, variational principles of elastodynamics, complete solutions of elasticity, formulation of two-dimensional problems, solutions to particular three-dimensional boundary value problems of elastostatics, solutions to particular two-dimensional boundary value problems of elastostatics, solutions to particular three-dimensional initial-boundary value problems of elastics, solutions to particular two-dimensional initial-boundary problems of elastodynamics, one-dimensional solutions of elastodynamics). In this sense the reader (beginners or advancers) get a complete overview of the mathematical theory of elasticity, that means the fundamentals and applications. Throughout the book the direct notation and the Cartesian coordinates are used. The book can serve as a main textbook for a wide range of readers, particularly graduate and phd students in engineering, applied mathematics and physics, as well as researchers in modern theory of continuum mechanics.

H. Altenbach

Kreißig, R.; Benedix, U.:
Höhere Technische Mechanik
Lehr- und Übungsbuch
177 S. ISBN 3-211-83813-9, € 29,80
Springer Verlag Wien New York 2002

The intention of this textbook is indicated in the subtitle: It covers the content of a half-year introductory class, giving not too detailled insight in the topics of

- linear elasticity
- mathematical formalism of tensorial equations
- physical background of continuum mechanics
- some analytical solution technique
- at last, the numerical solution of boundary value problems by FEM

Such a plentitude of points cannot be treated exhaustively in one book. Accordingly, no general introduction in tensor calculus or material theory is given. However, facts of predominant importance for understanding the matter have been laid down in a broad enough manner. Examples are the derivation of Cauchy's local field equation from global balance of momentum, or the introduction of the linear strain tensor from Green's strain that is expressed as a difference of metric. Also different material symmetry classes are mentioned.

The book's formal style is adequate and up-to-date. The authors avoid component formulae and elements of differential size. The index notation in an outsigned orthogonal base that is well suited for most applications is preferred to a more general formulation. Nevertheless the usual symbolic and mixed (component matrix and base vectors) notations are introduced and applied e.g. to cylindrical coordinates.

A detailed derivation of the finite element method for a thermoelastic orthotropic material out of the scrap features a 4-node rectangular element that is well suited for didactic purposes. Here, a compact matrix formulation is used.

The book contains a number of exellently worked examples for each section. They are useful for independent lecture by the students and do not prerequisite understanding of the full teaching content.

The outlines are clear and the writing is well understandable, held in a motivating style and the amount of topics is taylored to the given purpose of the textbook. There is a small list of suitable literature, providing help to the interested students to get deeper insight to the distinct topics, if desired.

The book's advantage is providing guidance to the reader through a difficult area of technical science. The strong focus and comprehension in references is another pro. Students of third year will certainly benefit most of the book. It is not intended as a reference book and for advanced graduate level there are appropriate books available and mentioned by the authors.

M. Schurig

Rappaz, M. ; Bellet, M. ;Deville, M. :
Numerical Modelling in Materials Science Engineering
Springer Verlag Berlin Heidelberg, New York, 2003
286 figs., 540 pp, USD 89,95
ISBN 3-540-42676-0

The authors attempt to acquaint the materials science student or the engineer with currently employed numerical methods in the fields of solid and fluid mechanics. Apart from the finite difference method (Chapter 2), the finite element method (Chapter 3) and elements of numerical algorithms (Chapter 4), the authors treat inverse methods (Chapter 8) and stochastic Monte Carlo methods (Chapter 9) such as random walkers and cellular automata. The remaining chapters are devoted to the topics of phase transformations (Chapter 5), deformations of solids (Chapter 6), and incompressible fluid flow (Chapter 7). For each of these subjects, the authors begin with the relevant constitutive equations followed by a description of important numerical aspects and a selection of relevant applications. It is possible to split the nine chapters into four main parts: (I) Introduction (Chapter 1), (II) Basic numerical methods (Chapter 2-4), (III) Constitutive modelling and numerical implementation (Chapter 5-7), (IV) Advanced numerical modelling (Chapter 8-9).

The book begins with an introductory chapter about continuous media where the balance and basic consitutive equations for mass, momentum, energy and solute are established. Using a unified presentation of the conservation equations the authors manage to provide a nicely compact description of advection-diffusion and thermo-mechanical problems including the choice of suitable boundary conditions. The understanding of the theoretical background is facilitated by several illustrative drawings concerning e.g. the physical meaning of the boundary conditions encountered in the context of the solute diffusion equation.

The next two chapters treat the most important aspects of the finite difference and the finite element method. To begin, the concept of the finite difference method is explained using the one-dimensional example of solute diffusion, with and without advective transport, for both stationary and non stationary cases. The distinction between the explicit and the implicit procedure and their stability properties can be well understood before the authors proceed to extend their formulation to two- and three-dimensional geometries. Of positive note is the fact that they succeed to explain the method compactly (in 45 pages), yet in sufficient detail to be implemented by the reader itself (even for multi-dimensional initial boundary value problems). This holds in principle as well for Chapter 3 (finite element method). Here, the emphasis is on the use of this method to solve linear problems. Nevertheless, the most important aspects, e.g., the choice of the interpolation functions, numerical integration procedures, the formulation of partial differential equations in weak form, as well as the assembly procedure, are discussed. The solution of non-linear finite element equations is included in Chapter 4 (elements of numerical algorithms), which presents at the beginning various algorithms for mesh generation. Very interesting is in the following the discussion of several solvers for linear equation systems which can be divided into two groups, direct solvers and iterative solvers. The issue whether a global finite element equation system is more efficiently solved directly or iteratively crucially depends on the number of equations and the condition of the equation system. The latter is often linked to the properties of the material under investigation and as such is also important for the use of the method in material science. A weak point of this chapter is the fact that the quasi-Newton method is not discussed. Its performance is much stronger than the modified Newton method (referred to as Picard's method by the authors). Especially in the context of non-linear problems, the use of line searches can improve the robustness of the solution noticeably. This aspect is also missing.

One of the most impressive chapters in the book is the one about phase transformations. The reader feels the enthusiasm of the writers. A wide range of important issues is thoroughly described. Starting from a review about phase diagrams and the equilibrium conditions holding at the interface between two phases, the authors introduce the average continuity equations of the multi-phase problem. After the presentation of suitable numerical methods to track an interface and to treat the average equations, these are applied to the modelling of multi-scale processes and the calculation of microstructures. Chapter 6 (deformation of solids) concentrates on elasto-(visco)plastic material behaviour and frictional contact. Several pages are devoted to numerically-robust strategies to deal with contact of geometrically complex structural components. The chapter is in particular interesting for scientists working on forming problems. The main part III ends with Chapter 7 (incompressible fluid flow), where suitable constitutive relations between the stress tensor and the velocity gradients to describe Newtonian and Non Newtonian fluids are introduced. Special emphasis is dedicated to the formulation of the boundary and initial conditions (also at interfaces) and the numerical treatment of the Navier-Stokes problem by means of finite-difference and finite-element schemes. As it is well-known, the advection terms need special attention. A particular interest therefore lies on upwind schemes. Chapter 8 (inverse problems) is valuabe for the material scientist who needs to identify model parameters on the basis of experimental results. The linear and a non linear version of the least squares method are explained followed by a short section about possible "ill-posed" problems and several useful examples. The last very short chapter gives an interesting and very compact but, naturally, a little superficial overview about the method of random number generation, the use of Markov chains, the Monte Carlo, Ising and Potts models as well as deterministic and cellular automata.

In summary the book offers an impressive and excellent overview of a large variety of important aspects in the broad field of numerical modelling in material science and engineering. The authors included many meaningful and scientifically interesting examples. These are very valuable not only for students who might work with the book in their lectures but also for the advanced computationally-oriented reader interested looking into new areas of research. A further positive aspect of the book is the clear organization enhanced by the overviews about the key objectives preceding each chapter. In order to facilitate understanding, exercises are offered at the end of each chapter. In addition reference to further literature, mainly text books, is given chapter-wise. A small disadvantage of the book is that it touches several topics only superficially. However, it is obvious that taking into account the great bredth of the presented material, this was hardly avoidable. To conclude, the book is highly recommendable to advanced students as well as scientists in the fields of engineering and material science.

S. Reese

Hutter, K.:
Fluid- und Thermodynamik. Eine Einführung
Zweite Auflage, 453 S., 194 Abb.
Springer-Verlag Berlin Heidelberg, 2003, € 49,95
ISBN 3-540-43734-7

This is the second edition of the well proved introduction to the fundamentals of fluid- and thermodynamics issued in 1995. The book stems from a 1-semester course delivered for students of engineering. Starting out with the fundamental ideas and concepts of fluid- and thermodynamics in a uniform representation, numerous applications and examples are discussed. The author chooses an inductive way, that means, he does not begin with the axioms of continuum physics, but he starts out with fluid dynamics. This part takes about the first half of the book, so that properly speaking, it consists of two introductions, one to fluid dynamics and another one to thermodynamics, the common basis of which is the field formulation of continuum physics.

In detail the book encludes the following chapters: introduction, hydrostatics, hydrodynamics of ideal fluids, viscous fluids, pipe flow, thermodynamics, gasdynamics, dimensional analysis. A brief supplement on vector analysis and integral theorems completes the book.

The first part of the book is written more conventionally within the framework of technical mechanics. Here students of engineering can find a lot of important applications.

The second part on thermodynamics is much less conventional than the first one. It is based on modern thermodynamics in a field formulation and demonstrates well the connection between the latter and that of discrete systems. The first law of closed discrete systems in conservative external fields is discussed and proved for open discrete systems at rest. The second law is introduced by the Sears-Kestin statement by which also the adiabatic unattainability of the states below the reversible adiabatic process in the u-v-diagram is proved. Simple examples for demonstrating the concept of irreversibility are presented.

A brief consideration of Pfaffians (but only for two variables) makes it possible to derive the thermostatic temperature and the entropy in equilibrium. The dissipation inequality of general discrete systems is motivated in a sub-chapter, and a field formulation in the sense of Rational Thermodynamics including the concepts equipresence and objectivity is discussed. The chapter "Thermodynamics" is finished by examples (especially the heat-conducting viscous fluid) and by considering state equations describing equilibria.

Chapter seven "Gasdynamics" is again conventional with respect to the use of the hypothesis of local equilibrium. The propagation of small disturbances in a gas, the theory of stationary isentropic flows, and singular surfaces in fields are treated. Additionally, the book closes with a brief, but extensive consideration of dimensional analysis.

This very clearly written book is more than only an "introduction", because it contains more topics than those which can be lectured in one semester. The part "Fluid Dynamics" can be found elsewhere, but perhaps not in this elucidating formulation. The part "Thermodynamics" introduces to students of engineering a new basis and a modern presentation of thermodynamical facts. It is desirable that this kind of lecturing may find its way also to teaching technical thermodynamics. This book can be warmly recommended not only to students of mechanics, thermodynamics, mechanical and chemical engineering and physics, but it is also very useful for lecturers in these fields for preparing their courses.

W. Muschik

Dhondt, G.:
The finite element method for three-dimensional thermomechanical applications
Published by Wiley & Sons Ltd, Chichester, 2004
96 illustrations, 340 pages
ISBN 0-470-85752-8, € 99,90

The book under consideration, according to the author, treats the theoretical background of the free available finite element software Calculix. Thus, the book is aimed at all users of the particular finite element program. However, all other people like graduate students and users of the finite element technology might also read it. The author wrote the book in addition to his work in industry. In this sense, the work has to be appreciated.

The book is divided into 7 chapters. It starts from the basics of continuum mechanics, goes through dynamical problems, elastic and inelastic, isotropic and anisotropic constitutive models for elastomers and metals, questions with regards to numerical implementations into finite element programs, and concludes with aspects of heat transfer.

In *Chapter 1* an introduction is given in view of continuum mechanics and the theory of materials, such as kinematics, balance relations, objectivity, materials of grade *n* and so forth. The notation changes between tensors as linear mappings and the older applications of indices, which is similar to Eringen's book on continuum mechanics. In this respect, it becomes obvious that the author was a student of A. Cemal Eringen. The chapter concludes with thermoelastic materials, linear elasticity as well as fluids. *Chapter 2* is dedicated to applications of linear problems. Particularly, its transition to finite element programs is described (shape functions, element types, integration formulas, etc.). In this context, the author also treats numerical problems of locking phenomena. A particular attention is focused on the difficult task of boundary conditions such as multiple point constraints, not straight reactions as well as centrifugal and temperature loadings. Furthermore, the basics of modal analysis, cyclic symmetry and integration formulas for dynamical systems are introduced. In *Chapter 3* some of these contents are extended to geometrically non-linear problems.

The second half of the books deals with physically non-linear problems, e.g. the incorporation of constitutive models is recapped. In *Chapter* 4 the book starts with hyperelasticity. Particularly, the concept of polyconvexity is recalled which seems to me not to be suited for the target group of the book. The explanation of polyconvexity does not indicate that each applied strain-energy functions is of this type. Most of the currently applied models (Arruda-Boyce, Mooney-Rivlin, Ogden) are summarized, e.g. its stress and tangent computation. Afterwards, anisotropic hyperelasticity is briefly discussed. *Chapter 5* comprises J_2-plasticity (rate-independent formulation) with isotropic and kinematic hardening resulting in the radial-return method for calculating the stresses within a global Newton-like iteration scheme. Accordingly, the consistent tangent operator is derived. In order to incorporate anisotropy into the representation, small strain single crystal plasticity (rate-dependent formulation) is presented. Rate-independent finite strain elastoplasticity is taken in *Chapter 6* into account. Again, stress algorithms and consistent tangent formulations are extensively derived. The final chapter, *Chapter 7*, is dedicated to heat transfer, where all finite element matrices and the time integration formulas are derived.

The book is very helpful for all those interested in implementing existing constitutive models in their own FE-codes. In this respect, it gives a certain overview of elastic and inelastic constitutive equations which are established in the community and very new material descriptions (for example, anisotropic hyperelasticity) of which the interest will grow. In connection with this, it is a good recapitulation of existing constitutive equation. Of course, it picks out only a very few models of the literature. However, most of them are also contained in commercial finite codes. In this respect, it has to be remarked that the citation of original literature could be improved. A particular attention is focused on boundary condition, which is frequently kept short in finite element text books. In contrast to this, it must be remarked that there is also a certain drawback in view of the notation which changes between index notation and bold-faced letters for tensorial quantities and bold-faced letters for matrices and letters in square brackets and braces. Particularly, the derivation of expression formulated in index notation is difficult to follow (if one does not use it often). Some sections would benefit from revision, because the didactics and the motivation could be improved and extended. Therefore, I would appreciate a revised edition of this interesting book which enriches the literature of non-linear finite element technology.

S. Hartmann

Rösler, J.; Harders, H.; Bäker, M.:
Mechanisches Verhalten der Werkstoffe
B.G. Teubner, Stuttgart-Leipzig-Wiesbaden 2003
296 illustrations, 28 tables and 31 exercises, 442 pages
ISBN 3-519-00438-0, € 29,90

One of the main topics in solid mechanics and material science is the description of the material behaviour. The importance of this topic is connected with many applications. For example, each designer needs a suitable description of the material behaviour resulting in mathematical expressions which can be used in structural analysis based on computer codes. Or people dealing with material testing have to compare the test results with theoretical predictions by using models of material description.

A huge gap enduringly exists between material science and the solid mechanics approach. To bring together both approaches, a new research field has been established (mechanics of materials or better the German original term Werkstoffmechanik) and many conferences, workshops, etc. were organized on this issue. The suggested solutions of the open questions are often little convincing since the scientists in this field mostly prefer the material science *or* the solid mechanics background, but not joint ideas. In addition, too many engineers are not sufficiently well educated in both disciplines.

The basic idea of the authors of the present book is to offer a common textbook for both students in material science and solid mechanics, as well as for students of other engineering disciplines who study in the last year of the undergraduate level. It is divided into 10 chapters (structure of materials, elastic behaviour, plasticity and failure, stress concentrations, fracture mechanics, mechanical behaviour of metals, ceramics, and polymers, fatigue of materials, creep), problems and their solutions (chapters 11 and 12) and 4 appendices (tensor calculus, Miller's and Miller-Bravais' indices, thermodynamical foundations, *J*-integral). In this sense the reader of the textbook will get an exhaustive introduction into the description of the mechanical behaviour of materials. The starting point in each special case of the material behaviour is given by some results of physics or material science (experimental observations or theoretical models). After this the authors try to find a suitable description by different types of mathematical equations (mostly related to the phenomenological behaviour, but founded on the micro- or mesoscopic experience). The reviewer can make the conclusion that the textbook is in this sense an extension of any textbook in material science or solid mechanics. In addition, it must be noted that the authors present the contents in a suitable form for undergraduate students (many helpful illustrations, problems with solutions, etc.). It can be recommended as an introduction to this topic.

It should be pointed out that in the case of a 2nd edition some parts of the present book should be revised by people with a more solid mechanics background. For example, the brief introduction to tensor calculus is partly unsatisfying. In addition, the discussion of the generalized Hooke's law can be extended since the tensorial description allows for the description of material symmetries in more detail.

As a conclusion, this book is highly recommended to all people who intend to get more knowledge in the description of material behaviour.

H.Altenbach