Rezensionen

Abeyaratne, R.; Knowles, J. K.:
Evolution of Phase Transitions – A Continuum Theory
Cambridge, University Press, 2006, USD 85,00
ISBN-13: 9780521661478, ISBN-10: 0521661471

This book is closely related to K. Bhattacharya's book on *Microstructure of Martensite*, (Oxford Univ. Press, 2003), since both books are dealing with martensite and its continuum thermodynamical and mechanical treatment. The book at hand deals now with the development of a new phase in a one-dimensional setting separated from the old phase by a moving interface. Since also inertia terms are considered, the case of shock waves is included in the treatment. The material is characterized by a non-convex function on the strain-stress space with several energy wells representing the parent phase as well as several types of the product phase. All jump conditions (conservation conditions) are demonstrated and applied. Several important cases are worked out in an instructive way. The reader can follow them very easily, since no specific mathematic requirements are implicated. Sometimes the notation is not fully consistent. On page 38 the symbol $\in$ is used to denote a parameter, on page $\in$ ($\hat{\in}$) is used for the internal energy. Then, on page 36 the symbol ε is used for the internal energy. Only as a remark, γ is used for the strain – in the open literature, however, it is often reserved for the surface (interface) energy. Some remarks are necessary especially for those readers who want to get a full picture.

The internal and free energy (ε or $\in$, φ) are not explicitly split into a chemical part and a mechanical part. However, the chemical part refers to the atomic arrangement. The difference between the chemical energy contributions of the parent and the product phase is often much higher than the mechanical contributions. In many cases the chemical energy difference drives a process and the mechanical terms are responsible for the variant selection. Of course, both terms, together with the potential energy of the loading system, reflect the entire energy content.

The term "surface energy" is mentioned briefly on page 40. Of course, it does not appear in the jump conditions, since the book uses a one-dimensional setting and no curved interfaces. However, in Part V of the book sequences of variants and twins are dealt with. Here it should be mentioned that the width of a twin band can only be understood by studying the interaction of strain energy and surface energy (see Sections 7, 11 of Khachaturyan's book from 1983 (Theory of Structural Transformations in Solids, John Wiley & Sons, New York et al., 1983), later Yan et al. (1997), P. Müller (2000), H. Petryk et al. (2003), F.D. Fischer et al. (2003)). The contribution of the surface energy typically appears at the usually plane interfaces between (twin-related) pairs of variants or a twin and the parent phase. The surface energy is also responsible for the splitting of the ends of the twin bands into "fingers". Recently, it has been found that the martensitic transformation in nanoparticles does not necessarily entail the formation of habit planes (interface parent phase/product phase). Nanograins are rather entirely filled by twin-related variants (see Waitz et al. (2005), (2007)). Of course, in this case both the interface energy between the variants as well as the interface energy along the surface of the grain (replacing the local strain energy) are of direct relevance.

With respect to physics of phase transformations as Example 1, Section 5.4, the Van der Waals equation for fluids/gases is outlined. Although its mathematical structure is interesting and leads to the prominent non-convex (or non-concave) pressure-volume diagram, its treatment within the context of martensitic transformation may be seen as somewhat strange. Totally different physical mechanisms are behind it, and a direct application of the "martensite mechanics" may be irritating for some readers. Section 8 deals with the "Kinetics and Nucleation" and gives practical hints how to deal with the kinetics of phase transformation in the sense of an interface motion. Section 8.5 reports a rather mechanistic point of view of nucleation. However, a more physically based understanding can only be obtained by means of molecular dynamics and – to a certain amount – the phase field concept (see Khachaturyan et al. (Acta Mater 2007)).

Mass flow (i.e. the flux of individual components in the bulk and near/across the interface) is not dealt with in this book. Anybody interested in diffusional phase transformations does not find any hint (neither with respect to the thermodynamic force nor with respect to kinetics).

The book can be recommended as a collection of well worked-out samples dealing with the motion of interfaces ("jumps") without any mass flow in a one-dimensional setting from the mechanical and thermodynamical point of view. As it is already mentioned, the book is not difficult to read and can also be recommended as a text book for students and for engineers.

F.D. Fischer

Bertram, A.:

Elasticity and Plasticity of Large Deformations - An Introduction

Springer, Berlin, 1. Auflage (2005), 326 Seiten, € 74,85
ISBN-10: 3540240330, ISBN-13: 978-3540240334

Rather than a treatise on Elasticity and Plasticity, this is at first sight a textbook on Continuum Mechanics applied to Elasticity and Plasticity. The title therefore may be considered as somewhat misleading and the first sentence of the back cover "The book offers a careful introduction to modern non-linear mechanics" provides a much better description of his content and purpose. Yet and undoubtedly, the main focus of the book is indeed on plasticity, but as advocated in the introduction and brilliantly shown in the book itself a proper development of large strain plasticity must rely on a deep understanding of elasticity.

The author clearly assumes his affiliation to the "Berlin school of continuum mechanics", a fair indication that mathematical accurateness will be important, as well a clear distinction between the assumed primitive concepts and the consequences that may be derived from them. By the way the introduction is quite explicit and the potential reader is strongly advised to read it carefully to decide whether he should continue or not.

Roughly speaking the book is divided in four parts of similar importance, 80 pages for each of the first three respectively devoted to the mathematical background, continuum mechanics in general and elasticity, while the remaining 60 pages deal with the central subject, plasticity.

Obviously the first part "Mathematical preparation" is of utmost importance. Yet as the notations are clearly stated at the beginning, a reader with some experience can easily skip through it rather quickly. It should also be noted that, although not restricted to orthonormal coordinate systems, the presentation use direct tensor notation which makes it easy to follow without focussing on covariant or contravariant components.

The second part consists in a condensed presentation of "modern continuum mechanics" as formalized for instance in the famous Truesdell-Toupin and Truesdell-Noll treatises. It will therefore sound quite standard for readers already familiar with these ideas; the younger generations, however, may find it here presented in a concise yet faithful way. Worth mentioning are also some special aspects which are here emphasized more than usual, in particular the distinction between objectivity and invariance under superimposed rigid motions and the treatment of thermomechanical constraints like temperature-dependant incompressibility.

The third part deals with elasticity, being defined by the stress being a function of the strain, while the more usual hyperelastic case defined from an elastic energy, is briefly discussed later. Special emphasis is laid upon the change of reference placement and the associated concepts of material symmetry and elastic isomorphy which will later play an essential part in the development of plasticity. Thermoelasticity is presented as well and some examples or applications are given in particular through the use of universal solutions.

The final part, plasticity is the in fact original part since the rest consists in known material, even if sometimes originally presented. Introducing the plastic behaviour within the context of rational continuum mechanics and thermodynamics has long been recognized as a challenge and the present presentation is a reasonable attempt to do this, starting from the concept of material with elastic range but processing it sufficiently to account for the generally accepted modern aspects of plasticity like isotropic and kinematic hardening, consistency conditions, intermediate configurations. Thermoplasticity and viscoplasticity are also briefly mentioned, while the book ends with a presentation of the very important special case of crystal plasticity.

As a conclusion this book will be appreciated by two different types of readers: somebody looking for an introduction to modern continuum mechanics for solid materials (simple fluids are defined but not covered) will find it here in a both concise and reasonably complete way. It should be emphasized that the high degree of mathematical formulation should not be a major obstacle for anybody even if reluctant to this kind of approach: I would then advise him to completely skip the first part and starts from the second where all concepts are also discussed and motivated in a physical way; he may then find reasons to go back to the mathematical preliminaries.

More advanced readers will be interested by an original vision of plasticity, successfully combining the required mathematical precision and the necessary physical motivations into a consistent and comprehensive framework for the description of large strain plasticity which, though important for many applications, still remains a controversial subject.

F. Sidoroff

Mao-Hong Yu:

Generalized Plasticity

Springer 2006, 468 S., 315 Abb., 22 Tab.
ISBN 3-540-25127-8, € 129,95

The main focus of the book lies on the description of the yield locus of metallic and mineral materials. As the whole book is entirely restricted to isotropic behaviour, only isotropic criteria are considered. The most well-known are, of course, the Tresca criterion and the Huber-von Mises one. Yu added a third one, which he calls the *twin-shear criterion*, similar to the Tresca one. He then gives general presentations of a whole bunch of isotropic criteria, with the before mentioned ones as particular cases. This general form with three constants includes also pressure-sensitive ones with tension/compression asymmetry.

Since many of these criteria contain corners, they cannot be directly applied for normality rules, but only after an appropriate regularization. Different choices for regularizations are demonstrated.

The "general" theory of plasticity is limited to small deformations and moves along the classical lines with normality. Hardening is not an important issue in this book. There is a chapter on concrete plasticity, which will not be present in most of the books on plasticity. The rest of the book is dedicated to various application of the method of characteristics, including plane strain, plane stress, rotational symmetry, crack tips, limit load and shakedown analysis, etc.

All in all, most of the topics of high importance have been excluded from the book, e.g., anisotropy, large deformations, hardening, etc. So the "generality" of the book is rather limited, but it will certainly satisfy particular research interests.

A. Bertram

Papula, L.:
Mathematik für Ingenieure und Naturwissenschaftler, Band 1
Vieweg Verlag, Wiesbaden, 2007
11., verbesserte und erweiterte Auflage
683 Seiten, 493 Abb., € 29,80
ISBN 978-3-8348-0224-8

Seit Jahren bewährt sich die Buchreihe von Papula beim Übergang von der Schule zum Studium sowie während des Studiums. Der Band 1 liegt nunmehr in einer überarbeiteten und erweiterten Auflage vor. Erfahrungsgemäß gibt es zu Studienbeginn in den technischen Fächern viele Probleme mit den mathematischen Vorkenntnissen. Vielerorts werden daher Brückenkurse angeboten um die Kenntnisse aufzufrischen. Dafür gibt es auch eine große Auswahl an Literatur, wobei nach meiner Meinung die Bücher von Papula eine herausragende Stellung einnehmen und uneingeschränkt zu empfehlen sind. Band 1 beinhaltet unter anderen die Lösung von Gleichungen und Gleichungssystemen, Vektoralgebra und ihre Anwendung in der Geometrie, die Untersuchung verschiedenster Funktionen (Kurvendiskussion), die Integral- und Differenzialrechnung sowie Potenzreihen. Zu allen Themen gibt es neben Beispielen im Text viele Übungsaufgaben zu denen im Anhang auch die Lösungen angegeben sind. Die Beispiele sind anschaulich illustriert. Anwendungen des vermittelten Stoffes in der Technik sind ebenfalls in das Buch integriert, wobei hier einem Studienanfänger noch das Hintergrundwissen fehlt. Wichtige Definitionen, Merksätze und Zusammenfassungen sind hervorgehoben und ergeben so einen „roten Faden“ durch das Buch. Alle Aufgaben sind so angelegt, dass sie mit Bleistift, Papier und evtl. einem Taschenrechner gelöst werden können. Die Unterstützung durch Computeralgebra-Systeme sieht der Autor nur als Hilfsmittel, das die grundlegenden Kenntnisse nicht ersetzten kann. Diese Einstellung kann man nur unterstützen. Das Buch wird sich jedem Studenten als wertvoller Begleiter durch das Studium erweisen.

W. Lenz