## Process Modeling of Metal Forming and Thermomechanical Treatment

***Edited by C.R. Boer, N. Rebelo, H. Rydstad and G. Schroder***

*(Springer-Verlag, 1986)*

*Process Modeling of Metal Forming and Thermomechanical Treatment* is a timely book that reviews the multidisciplinary nature of metal-forming modeling technology. Although the book is intended for engineers, students, and scientists in the manufacturing industry, it is the first of its kind that could be adopted as a text for mechanical metallurgists interested in applying the finite-element method to metal deformation and thermal problems. The strengths of the book are in its condensed reviews of plasticity, heat transfer, and the finite-element method, in which the authors present the basic concepts relevant to metal-forming processes. The authors clarify that process modeling refers to the mathematical description which is required to quantitatively describe the essential characteristics of a forming process. Process modeling of metal forming is based upon extensive research work by the authors conducted at the Brown, Boveri Research Center, Dattwil, Switzerland, a leading industrial company, during 1980–1985. The authors supply several examples of process modeling as applied to forging, rolling, drawing, and thermomechanical treatments and draw upon their considerable experience in this area.

The first section of the book, Mathematical Modeling, reviews the essential concepts associated with the infinitesimal theory of plasticity, problem solution approach, and the more classical elementary analysis methods such as the "slab and upper-bound methods."

Next, the finite-element method is introduced with application to both stress and thermal analyses. Distinction is made between displacement-based "elastic-plastic" formulations and velocity-based "rigid-plastic" or flow formulations. The authors note that the difficulties associated with earlier infinitesimal elasto-plastic formulations have been largely overcome by updated Lagrangean forms using appropriate time integration schemes. Although from a purely mechanical point of view the updated Lagrangean formulation (which also contains the elastic solution) is more complete, the rigid-plastic approach has lead the way due to earlier achievements. The authors have considerable experience with the rigid-plastic formulation, and applications presented in this book reflect programs implementing this approach. The section on finite-elements provides the necessary background and nomenclature required for a more in-depth review of the material on the two stress formulation methods and on thermal analysis methods.

Also included in this section are specifics on the modeling of forming processes, such as boundary conditions and the treatment of contact surfaces including friction.

The next section, Physical Modeling, discusses some physical techniques, such as plasticine models, that have historically been used to simulate actual material behavior during forming processes. As computing costs and complexities have steadily decreased, the physical modeling techniques have reached maturity and are now being widely replaced with the FEM-simulation methods, at least for two-dimensional simulations.

The next three sections cover the application of modeling techniques to forging, rolling, and drawing. Each section begins with a list and description of symbols used in the examples. The forging section includes examples of closed-die, upset, blade, and thin-rib forgings and a "coupled" or non-isothermal FEM analysis. The section on rolling concentrates primarily on "roll pass design" and integration into a computerized flow process. Modeling of the drawing process is approached from the "upper-bound" method, and an example of three-dimensional FEM drawing simulation is presented. The authors point out some unique complexities associated with obtaining solutions to three-dimensional problems.

The last section of applications describes modeling of thermomechanical treatments. This section includes methods for the experimental determination of heat transfer coefficients that are required for process modeling, a tutorial on the basic principles of heat transfer, and examples of applying modeling techniques to a quenching operation and a heat treatment process.

The authors' comments on the outlook for process modeling deserve to be paraphrased here and somewhat extended by this reviewer. The future for computer-assisted process modeling is very promising and has the potential to greatly impact conventional methods of fabrication design. Computing costs steadily decline as computing capability, accessibility, and expertise continually rise. To fully exploit this technology will require advances in numerical methods, for example, to economically simulate complex three-dimensional problems and to address non-isotropic plasticity. There is a need for improved, numerically efficient constitutive material models that include the material response to deformation, such as texture development, recrystallization, and/or grain growth. These advances will require the efforts of applied mechanicians, code developers, and materials scientists. On the other hand, assisting computer process modeling into the production environment will require special efforts in training industrial personnel and in educating engineers and metallurgists in our universities.

*Process Modeling of Metal Forming and Thermomechanical Treatment* is a thorough presentation of the essentials associated with computer-assisted simulation of metal forming. It is appropriate for practicing engineers and for both mechanical and metallurgical engineering students entering this relatively new realm of manufacturing technology.

*Reviewer: Elane C. Flower is a metallurgist in the Advanced Engineering Analysis Group, Mechanical Engineering Department, at Lawrence Livermore National Laboratory.*

## CRC Handbook of Laser Science and Technology, Volume IV

***Edited by M.J. Weber***

*(CRC Press, 1986)*

This book is the fourth of an important five-volume handbook to be completed this year. The other volumes cover: I. Lasers and Masers; II. Gas Lasers; III. Optical Materials, Part 1–Nonlinear Optical Properties/Radiation Damage; IV. Optical Materials, Part 2–Properties; and V. Optical Materials, Part 3–Applications, Coatings, and Fabrication.

Editor Marvin Weber, head of Basic Materials Science at Lawrence Livermore National Laboratory, is eminently qualified and has performed his task just about as well as it could be done. Knowing how much work is involved in producing such a series, we must be thankful to him and to the contributors for a significant achievement.

As Weber explains in the introduction, a handbook can never be completely current with the literature. The first volume, published in 1982, covered the literature to about 1979; the current volume extends to 1982/83.

Volume IV consists of two sections. The first covers the fundamental properties of transmitting crystals, glasses, and plastics; filters; mirrors; and polarizers. For each group there is a series of tables. The tables for crystals, for example, give the crystal system, bandgap, transmission range, references to spectra, density, hardness, solubility, refractive indexes at different wavelengths and their temperature coefficients, dispersion parameters, a series of thermal parameters, and the piezo-optic and elastic constants.

The second section deals with special properties, covering the characteristics of linear electro-optical, magneto-optical, elasto-optical, and photorefractive materials as well as liquid crystals. For each

*Continued*



https://doi.org/10.1557/S0883769400068238 Published online by Cambridge University Press

group of properties in both sections, an introduction outlines the theory, experimental procedures, and selected references.

The index must be used with care to find the specific property of a specific material. In checking for the specific material directly, I found references to figures or tabulations dealing only with that material. Much additional information exists in the collective tables, but can be found only by looking up the particular property. The publisher does not make the task any easier, since the running head at the top of the page identifies only Section 1 or Section 2. The table of contents is quite brief and appears in an inconspicuous spot on the back of the last page of the introductory matter.

A brief scan located just a few errors, judged to be minor. In checking on ZnS, I found Table 1.1.1.2 gives the βZnS crystal system as cubic. Subsequent tables usually list merely "ZnS"; in Table 1.1.1.4.5 ZnS also appears in a hexagonal listing. In other places the listing is "ZnS (CVD)"; an examination of the data indicates that this must be the cubic form. Refractive index data on these materials are found in a variety of forms on pages 29, 31, 33, 234, 247, and 265. Some of these entries imply that ZnS is also available as "Irtran 2," for which "Infrared transmission" in the index also leads to additional data on page 242.

Having found some imperfections in this massive work, I can now complete my review by saying that I expect to find this volume very useful in my work and would hate to be without it. Most materials scientists will, I believe, feel the same way.

*Reviewer: Kurt Nassau is a member of the technical staff at AT&T Bell Laboratories, Murray Hill, NJ.*

## Strong Metal-Support Interactions

***Edited by R.T.K. Baker, S.J. Tauster, and J.A. Dumesic***

*(American Chemical Society, 1986)*

This volume in the ACS Symposium Series presents the papers from a symposium held at the 189th Meeting of the American Chemical Society in Miami Beach, Florida, April 28 through May 3, 1985. It includes 21 papers discussing metal-support interactions, a topic of continuing interest among catalytic chemists but now of importance to those involved in understanding other materials, such as metal-metal oxide interfaces in electronics. This symposium focuses on those aspects strongly coupled to heterogeneous catalysis.

The topics range from a review, through detailed microscopic and kinetic characterizations of high-surface-area catalysts, to important studies of model systems. This book brings together the thinking of experts from around the world who are working in this area.

Because of the detailed nature of these papers which, for the most part, represent new and ongoing research, the book will be most valuable to experts in the field. However, Tauster's overview is particularly noteworthy in its attempt to assess the present status and understanding of this important field. As such, it will be of considerable interest to newcomers to metal-support interactions. While the center of gravity of the reported work lies in the popular metal-titania systems, other areas are given sufficient coverage to provide useful breadth and an indication of the generality of the important metal-support interactions.

As a participant in this field, I found the papers to be of uniformly high quality and to contain interesting observations and speculations which stimulated anew my thinking on this subject.

*Reviewer: J.M. White is the Norman Hackerman Professor of Chemistry at the University of Texas at Austin.*

## Electron Energy Loss Spectroscopy in the Electron Microscope

***R.F. Egerton***

*(Plenum Press, 1986)*

Electron energy loss spectroscopy (EELS), as a technique for elemental analysis, dates from the pioneering work of Hillier and Baker at RCA in 1944. For much of the succeeding 40 years, EELS remained a laboratory curiosity, overshadowed by the successes of fluorescent x-ray microanalytical techniques. In the past ten years, however, with the development of electron microscopes combining small diameter probes, high beam energies, and good vacuum engineering, EELS has become an analytical tool of considerable importance. This new book, by one of the workers who has done most to establish the technique, finally marks the transition of transmission electron microscopy from a promising newcomer to an established performer.

The book is divided into five major sections, starting with an introduction and general survey of electron spectroscopy. Next comes a study of EELS instrumentation. This chapter is particularly welcome as it is perhaps the first detailed exposition of many of these topics in a readily accessible form. Anyone attempting to set up an EELS system for the first time will be grateful to have this material.

The next section, a detailed and thorough review of electron scattering theory, provides a comprehensive overview of all aspects of both elastic and inelastic scattering phenomena. While some of the theoretical material is quite advanced, the author has been careful to start each chapter with a review of basic concepts, and then build toward more complex ideas.

The last two chapters consider the application of EELS to qualitative and quantitative elemental analysis, and other applications of EELS including structural determinations using Extended Fine Structure (EXELFS), Near Edge Structure (XANE), and Compton Scattering methods.

The overall presentation of the book is good, although the reproduction of some of the experimental spectra, apparently photographed from screen displays, is less than ideal. Considerable care seems to have been taken to ensure uniform notation throughout the text and this, together with the careful explanations, excellent drawings, and practical illustrations, will make the book ideal for teaching use at the graduate level. The volume is further enhanced for use as a reference source by some useful appendices, such as a tabulation of characteristic plasmon loss values and a detailed listing of edge energies, a compilation in reasonably generic FORTRAN of the source code for some of the programs discussed in the text, and a good index.

The bibliography deserves a special word, as it is both comprehensive and fully annotated. Many of the references cited here are difficult to find elsewhere and this portion of the book will surely be one of the most heavily used. Anyone who is now using, or who is planning to use, EELS in an electron microscope will find this book invaluable as a reference and as an experimental guide.

*Reviewer: David C. Joy is a member of the technical staff at AT&T Bell Laboratories, Murray Hill, NJ.*

## Applied Polymer Science

***Edited by R.W. Tess and G.W. Poehlein***

*(American Chemical Society, 1985)*

*Applied Polymer Science* covers a wide range of topics in current applications of polymers. The volume is divided into eight segments, each containing several chapters and making a total of 54. An introduction by Herman Mark provides a historical perspective of the field of polymers. The chapter by C.E. Carraher, Jr. and R.B. Seymour lays the foundation for all subsequent chapters. The second segment reviews in depth various modes of polymerization, including major industrial processes, such as free-radical, ionic, and condensation reactions. Block copolymer and multicomponent systems are also discussed in separate chapters. The next segment deals with structure-property relationships, with specific concentration on transport behavior, fracture mechanics, and flammability. Up to this point, the volume reads more like a graduate-level text, all the subjects

*Continued*