Process Modeling of Metal Forming and Thermomechanical Treatment

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

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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.

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CRC Handbook of Laser Science and Technology, Volume IV

Edited by M.J. Weber

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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

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