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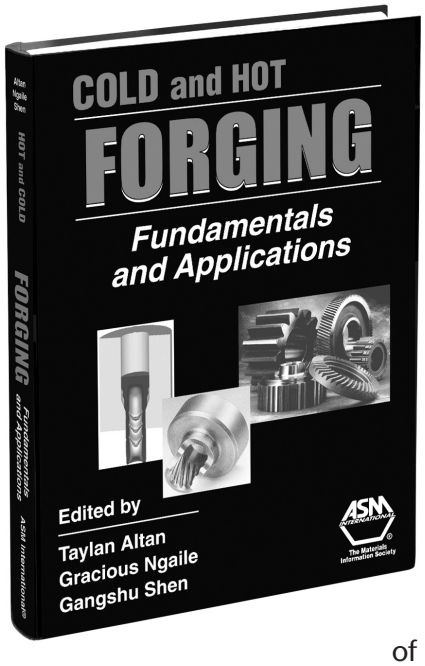

Cold and Hot Forging: Fundamentals and Applications

Edited by T. Altan, G. Ngaile and G. Shen • 2004
• Approx. 350 pages • ISBN: 0-87170-805-1 • ASM Publication

Among all manufacturing processes, forging technology has a special place because it can be used to produce parts of superior mechanical properties with minimum waste of material. Process selection and optimization are important because of the ever-increasing costs of material, energy, and labor. This reference book reviews the fundamentals of forging technology, the principal variables of the forging process and their interactions, and computer-aided techniques such as finite element analysis (FEA) for forging process and tooling design.

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Topics addressed include the flow behavior of the forged material under processing conditions; die geometry and die materials; friction and lubrication; the mechanics of deformation (strains and stresses); the characteristics of forging equipment; the geometry, tolerances, surface finish and mechanical properties of forgings; and the effects of the process on the environment. A major emphasis is on the latest developments in the design of forging operations and dies, and process modeling using FEA is discussed in all of the relevant chapters.

Several chapters of the book have appendices that consist of computer animations showing the results of FEA simulations for various forging operations. The appendices are provided in Microsoft PowerPoint on the CD-ROM included with the book.

Contents: Metal Forming Processes in Manufacturing • Forging Process-Variables and Descriptions • Plastic Deformation: Strain and Strain Rate • Flow Stress and Forgeability • Deformation: Complex State of Stress and Flow Rules • Temperatures and Heat Transfer • Friction and Lubrication • Simultaneous Determination of Flow Stress and Friction • Methods of Analysis for Forging Operations • Principles of Forging Machines • Presses and Hammers for Forging • Special Machines for Forging • Billet Separation • Process Design in Impression Die Forging • A Simplified Method to Estimate Forging Load in Impression Die Forging • Process Modeling in Impression Die Forging using FEA • Cold and Warm Forging • Process Modeling in Cold Forging using FEA • Microstructure Modeling in Forging • Isothermal and Hot Die Forging • Die Materials and Die Manufacturing • Die Failures in Cold and Hot Forging • Near Net Shape Forging and New Developments • Index

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Cold and Hot Forging – Fundamentals and Applications

(Edited by T. Altan, G. Ngaile and G. Shen)

Preface and Table of Contents

PREFACE

Among all manufacturing processes, forging technology has a special place because it helps to produce parts of superior mechanical properties with minimum waste of material. In forging, the starting material has a relatively simple geometry; this material is plastically deformed in one or more operations into a product of relatively complex configuration. Forging to net or to net shape dimensions drastically reduces metal removal requirements, resulting in significant material and energy savings. Forging usually requires relatively expensive tooling. Thus, the process is economically attractive when a large number of parts must be produced and/or when the mechanical properties required in the finished product can be obtained only by a forging process.

The ever-increasing costs of material, energy and especially manpower require that forging processes and tooling be designed and developed with minimum amount of trial and error with shortest possible lead times. Therefore, to remain competitive, the cost-effective application of computer aided techniques, i.e. CAD, CAM, CAE and especially Finite Element Analysis (FEA) based computer simulation, is an absolute necessity. The practical use of these techniques requires a thorough knowledge of the principal variables of the forging process and their interactions. These variables include: a) the flow behavior of the forged material under processing conditions, b) die geometry and materials, c) friction and lubrication, d) the mechanics of deformation, i.e. strains and stresses, e) the characteristics of the forging equipment, f) the geometry, tolerances, surface finish and mechanical properties of the forging, and g) the effects of the process on the environment.

There are many excellent hand books and technical papers on the technology of the forging. These principles are briefly reviewed in this book, but major emphasis is on the latest developments in the design of forging operations and dies. Thus, process modeling using FEA has been discussed in all appropriate chapters. The subject is introduced in Chapter 1 with a discussion of the position of metal forming processes in manufacturing. Chapter 2 considers forging process as a system consisting of several variables that interact with one another. This chapter also includes an overall review of the forging operations. The fundamental of plastic deformation, i.e. metal flow, flow stress of materials, testing methods to determine material properties, and flow rules are discussed in Chapters 3, 4 and 5. Chapters 6 and 8 cover the significant variables of the forging process such as friction, lubrication and temperatures. Chapter 9 is devoted to approximate methods for analyzing simple forging operations. Chapters 10 thru 13 discuss forging machines, including machines for shearing and pre-forming or material distribution. Process and die design, methods for estimating forging loads, and the application of FEA based process modeling in hot forging are discussed in Chapters 14, 15 and 16.

Chapters 17 and 18 cover cold and warm forging, including the application of FEA simulation in these processes. Microstructure modeling, using forging of high temperature alloys as example, is covered in Chapter 19, while Chapter 20 is devoted to isothermal and hot die forging of aerospace

alloys. Die materials, die manufacturing and die wear in hot and cold forging are discussed in Chapters 21 and 22.

Finally, Chapter 23 reviews the near net shape forging technology, including enclosed die forging, multiple-action tooling and the most recent developments in forging presses. This chapter also discusses briefly the future of forging technology in the global economy, the importance of information technology in the forge shop and finally, the need to continuously acquire knowledge on new methods and techniques to remain competitive.

Several chapters of the book (Chapters 4, 6, 7, 14, 15 and 17) have Appendices that consist of computer animations. These animations represent the results of FEA simulations for various forging operations. They are given in a CD that is included with this book. The reader is encouraged to utilize the CD and these Appendices in order to understand better and easier some of the fundamental issues discussed in corresponding chapters.

The preparation of this book has been partially supported by Jacob Wallenberg Foundation Prize, awarded to Dr. Taylan Altan by the Royal Swedish Academy of Engineering Sciences. The staff and the students of the Engineering Research Center for Net Shape Manufacturing (ERC/NSM) of The Ohio State University contributed significantly to the preparation of the book. Specifically, Mr. Pinak Barve, Graduate Research Associate, provided valuable assistance in preparing the text and the figures. Considerable information has been supplied by a large number of companies that support the forging research and development at the ERC/NSM. On behalf of the authors and the editors, I would like to thank all who made our work so much easier. Finally, I would like to thank my wife, Susan Altan, who has offered me enormous support and encouragement throughout the preparation of this book.

Taylan Altan
March 2004

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The Appendices are power point slides and animations. They are on the CD distributed with this book.