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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 handbooks and technical papers on the technology of the forging. These principles are reviewed briefly 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 fundamentals of plastic deformation, i.e., metal flow, flow stress of materials, testing methods to determine materials 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 through 13 discuss forging machines, including machines for shearing and pre-forming or materials 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 iso-
thermal 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) contain appendixes
that consist of presentation slides and computer animations. The 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 use the CD and these
appendixes in order to understand better and easier some of the fundamental issues
discussed in corresponding chapters.

The preparation of this book has been supported partially by the Jacob Wallenberg
Foundation Prize, awarded to Dr. Taylan Altan by the Royal Swedish Academy of
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