
Preface

The use of computational techniques is increasing day by day in the manufacturing sector. Process modeling and optimization with the help of computers can reduce expensive and time consuming experiments for manufacturing good quality products. Metal forming and machining are two prominent manufacturing processes. Both of these processes involve large deformation of elasto-plastic materials due to applied loads. In metal forming, the material is plastically deformed without causing fracture. On the other hand, in machining, the material is deformed till fracture, in order to remove material in the form of chips. To understand the physics of metal forming and machining processes, one needs to understand the kinematics of large deformation (dependence of deformation and its rate on displacement) as well as the constitutive behavior of elasto-plastic materials (dependence of internal forces on deformation and its rate). Once the physics is understood, these phenomena have to be converted to mathematical relations in the form of differential equations. The interaction of the work-piece with the tools/dies and other surroundings also needs to be expressed in a mathematical form (known as the boundary and initial conditions).

In this book, the first four chapters essentially discuss the physics of metal forming and machining processes. The physical behavior of the work-piece during the processes is modeled in the form of differential equations and boundary and initial conditions. One of the well-known mathematical techniques to solve differential equations and boundary and initial conditions is the finite element method. Chapters 5–7 describe the finite element formulations of metal forming processes using Eulerian and updated Lagrangian approaches and that of machining process using an Eulerian approach. Instead of physics-based modeling, the metal forming and machining processes can also be modeled by another approach using only empirical data and soft computing techniques. Chapter 8 introduces some soft computing techniques like neural networks, fuzzy set theory and genetic algorithms. Chapter 9 discusses the application of the soft computing techniques to metal forming and machining processes. Chapter 10 deals with optimization of metal forming and machining processes. Chapter 11 concludes the book. We feel that the physics-based finite element modeling and soft computing-based modeling are complementary to each other. However, readers interested only

in finite element modeling may go through Chapters 1–7. Similarly, the readers interested only in soft computing based modeling may read only Chapter 1 and Chapters 8–10.

This book is essentially for graduate students and researchers in the field of computational manufacturing. Some background in the areas of solid mechanics, finite element method and soft computing is desirable. For the benefit of readers, a brief review of these subjects is provided in Chapters 2, 5 and 8. The book can also be used as a textbook for a three-semester graduate level course (which can also be taken by senior undergraduate students) on modeling of metal forming and machining processes: the first course on theory of plasticity covering the first four chapters, the second course on finite element modeling of metal forming and machining processes covering Chapters 5–7 and the third course on soft computing modeling of metal forming and machining processes covering Chapters 8–10.

The major objective of this book is to stimulate the interest of readers in the area of computational manufacturing. We expect the book to be used as a source of direction rather than information. In order to provide an optimized treatment of the subject, we had to make quite a few simplifying assumptions. Although we have taken the utmost care to avoid errors, we would welcome details of errors and/or suggestions (preferably by e-mail) for improving future editions of the book. A number of books and papers have been consulted while preparing the draft of the book. A list of references has been provided at the end of each chapter. There may be some important works that may have been unintentionally omitted. We request the readers to bring any omissions to our notice.

The authors of this book have a long association with each other, since the second author (USD) came as a graduate student to the Indian Institute of Technology (IIT) Kanpur in 1991. The two authors have worked together in the area of finite element modeling for several years. In 1998, the second author shifted to IIT Guwahati, about 1500 km from Kanpur, as a faculty member. However, e-mails and inexpensive telephonic communications compensated for the geographical distance. Both authors have been teaching the courses on Solid Mechanics, Plasticity, Metal Forming and Machining at IIT Kanpur and IIT Guwahati for the past several years. Further, they have supervised several masters and doctoral students in the area of finite element and soft computing applications to metal forming and machining processes and other plasticity problems. Interaction with these students (whom they taught as well as supervised) has certainly helped in preparing the draft of this book. The authors thank all these students. The complete list is long. However, the first author (PMD) cannot avoid mentioning the names of the following: his past Ph.D. students—Sankar Dhar, N. Venkata Reddy (now colleague at IIT Kanpur), Uday S. Dixit (the second author of the book), his present Ph.D. students—Ravindra K. Saxena, Anupam Agrawal and Sachin S. Gautam and his past M.Tech. student—S.N. Vardhan. The first author (PMD) would also like to thank his family for providing the moral support while writing the book: his wife Rekha, his daughter Rashmi, his and his wife's brothers and sisters-in-law, his and his wife's sisters and brothers-in-law and the son-in-law.

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