Computational Plasticity

in Powder Forming Processes

Amir R. Khoei

The application of computer-aided engineering is essential in modern metal forming technology. Process modeling for the investigation and understanding of deformation mechanics has become a major concern in research, and the finite element simulation has assumed increased importance, particularly in the modeling of powder forming processes.

The main purpose of this book is to present the fundamentals and applications of finite element plasticity in powder forming analysis and technology. The book focuses on specific areas, such as large deformation, including: Lagrangian and arbitrary Lagrangian-Eulerian formulation, classical and modern constitutive theories, such as single-surface, double-surface and multi-surface plasticity models, endochronic plasticity theory, continuum model of frictional phenomena, a finite strain plasticity based on hypoelasto-plastic model, and finally, the presentation of pre- and post-processing of powder compaction software (PCS_SUT).

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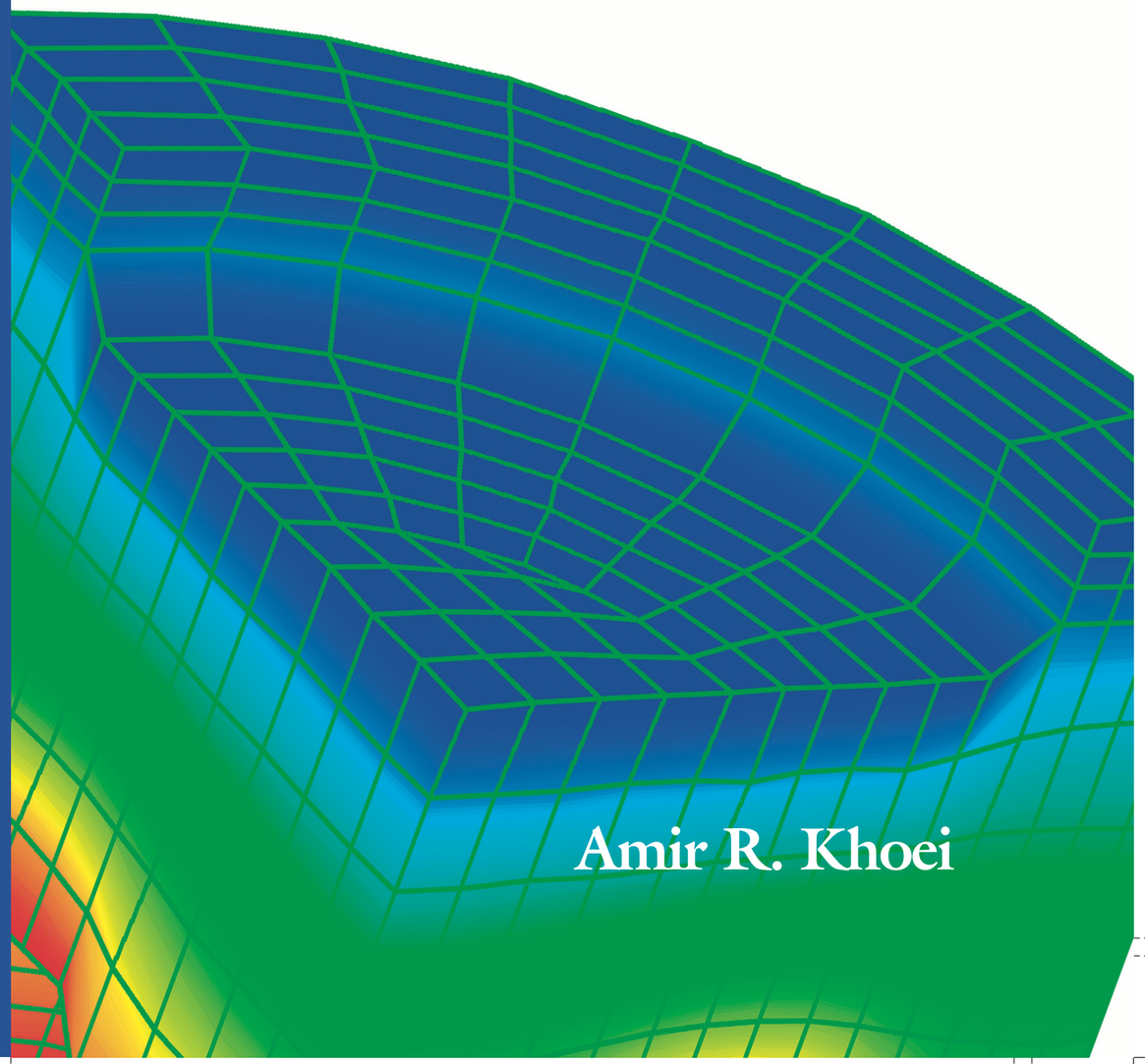

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To my wife and son

Azadeh and Arsalan

CONTENTS

Preface **vii**

1. Introduction **1**
1.1. Metal forming processes 1
1.2. Design of forming processes 4
1.3. Finite element analysis in metal forming 6
1.4. Powder compaction processes 7
1.5. Powder metallurgy technology 8
1.6. Mechanical behavior of powder 9
1.7. Numerical simulation of powder forming processes 11

2. Finite Element Method **19**
2.1. Introduction 19
2.2. Governing equations for powder forming analysis 21
2.3. Lagrangian formulation 22
2.4. Finite element discretization 26
2.5. Time domain discretization 29
2.6. Nonlinear iterative strategy 32
2.7. Arbitrary Lagrangian-Eulerian method 35
2.8. ALE governing equations 37

3. Powder Constitutive Models **44**
3.1. Introduction 44
3.2. Generalized plasticity 47
3.3. Plasticity models for porous materials 51
3.4. Plasticity models for granular materials 52
3.5. Plasticity models for powder materials 55
3.6. MCEC plasticity model 60
3.7. Double-surface plasticity model 63
3.8. The three-invariant single plasticity model 67
3.9. Integration of the constitutive relation 70

4. Boundary Friction Model **101**
4.1. Introduction 101
4.2. Physical aspects of friction 102

4.3. Plasticity theory of friction 104
4.4. Modeling of friction 110
4.5. Continuum model of friction 111
4.6. Interface element formulation 115

5. Application of Cap Plasticity Model 128
5.1. Introduction 128
5.2. Experimental investigation 129
5.3. Parameter determination 131
5.4. Application of MCEC plasticity model 133
5.5. Application of three-invariant single plasticity model 138

6. Error Estimation and Adaptivity 175
6.1. Introduction 175
6.2. Adaptive FEM strategy 177
6.3. Error estimation 178
6.4. Adaptive mesh refinement 180
6.5. Adaptive mesh generator 182
6.6. Mapping of variables 183
6.7. Error estimates and adaptive time stepping 188
6.8. Numerical simulation results 191

7. Advanced Plasticity Models 210
7.1. Introduction 210
7.2. Endochronic plasticity theory 211
7.3. Endochronic theory of plastic deviatoric deformation 212
7.4. Endochronic theory of plastic volumetric deformation 214
7.5. Endochronic theory of plastic volumetric and plastic deviatoric deformations 217
7.6. Endochronic theory of visco-plasticity 223
7.7. Multi-surface plasticity theory 224
7.8. Multi-surface theory of J_2 plasticity 226
7.9. Multi-surface theory of pressure-dependent plasticity 234

8. Finite Deformation Plasticity 246
8.1. Introduction 246
8.2. Finite deformation of endochronic plasticity 248
8.3. Numerical integration of hypoelasto-plastic equations 250
8.4. Finite deformation of endochronic visco-plasticity 256
8.5. Numerical examples of finite elasto- and visco-plasticity 259
8.6. Finite torsion of thin-walled tubes 262

9. Application of Advanced Plasticity Models 294
9.1. Introduction 294
9.2. Application of endochronic plasticity 296
9.3. Application of double-surface plasticity 304
9.4. Application of three-invariant single-cap plasticity 306

10. Discontinuous Displacements and Localization 358
10.1. Introduction 358
10.2. Causes of localization in solid mechanics 360
10.3. Governing equations of incompressible plasticity 361
10.4. Theory of Cosserat continuum 364
10.5. Adaptive strategy for discontinuous displacements 368
10.6. Numerical simulation results 371

11. Powder Compaction Software **403**
11.1. Introduction 403
11.2. Overview of the software environment 405
11.3. Pre-processing – mesh generation 407
11.4. The analysis utility environment 408
11.5. Post-processing 409

References **417**

Author Index **436**

Subject Index **442**

PREFACE

The application of computer-aided engineering is essential in modern metal forming technology. Process modeling for the investigation and understanding of deformation mechanics has become a major concern in research, and the finite element method has assumed increased importance, particularly in the modeling of powder forming processes. The finite element method emerges as the preferred approach and its flexibility leads to the development of powerful program packages capable of treating wide range of problems. The FE analysis provides detailed information on conditions within the processed material, which is often more complete than can be obtained even from elaborate physical experiments, and the numerical simulation makes it possible to examine a range of designs, or operating conditions economically. The main purpose of this book is to present the fundamentals and applications of finite element plasticity in powder forming analysis and technology.

The book is primarily written for graduate students and researchers (Masters and PhD students in Mechanical, Materials, Civil and Chemical Engineering). However, it will be useful to practicing engineers who have a good background in FEM and who are interested in applying this technique to the analysis of metal forming processes.

The book begins with a general background on the subject in Chapter 1. A general description of the governing equations for large deformation process of metal powder forming is given in Chapter 2 based on the Lagrangian and arbitrary Lagrangian-Eulerian formulation. Chapter 3 describes the mechanical behavior of powder materials using classical and modern constitutive theories. A combination of a Mohr-Coulomb and hardening cap model, a generalized double-surface plasticity and a three-invariant single plasticity theory are developed in this chapter in the concept of the generalized plasticity formulation. In Chapter 4, the general problem of formulating continuum models for frictional phenomena and of developing computational methods for analyzing these phenomena is introduced. Chapter 5 illustrates the applicability of the cap plasticity in simulating powder forming processes. Chapter 6 is devoted to the application of adaptive FEM strategy in the analysis of powder forming processes. In chapter 7, a new approach is developed based on an endochronic density-dependent plasticity model for describing the isothermal deformation behavior of powder materials. An application of the multi-surface plasticity theory is presented for pressure-independent and pressure-dependent materials in this chapter. In chapter 8, the numerical modeling of powder forming process is simulated by a finite strain plasticity based on hypoelasto-plastic formulation. Chapter 9 presents 2D and 3D numerical modeling of powder forming process using advanced plasticity models. In chapter 10, a computational algorithm is presented for dealing with softening plasticity due to material instability. Finally, the powder compaction software (PCS_SUT), which is designed for pre- and post-processing for computational simulation of the process compaction of powder is presented in Chapter 11.

Sincere thanks are due to a number of individuals. I wish to express my sincere gratitude to Professor Roland W. Lewis, University of Wales Swansea, who helped me to devote my careers to research in powder compaction. I am indebted to the predecessors of this research, in particular Professor D.T. Gethin, Dr. D.V. Tran, and Dr. R.S. Ransing, University of Wales Swansea, whose work formed the basis of the new developments reported here. I wish to thank my colleagues and former graduate students in the Department of Civil Engineering, Sharif University of Technology, who have contributed to the advances in the application of computational plasticity to powder forming; Professor M. Mofid, Dr. A. Bakhshiani, A.R. Azami, S.A. Gharehbaghi, S. Azizi, N. Jamali, A.R. Tabarraie, A. Riahi and M. Anahid. I also thank S. Azizi and A.R. Azami for their contribution in the preparation of this manuscript.

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