Miguel Vaz Junior, Eduardo A. de Souza Neto and Pablo A. Muñoz-Rojas (Eds.)

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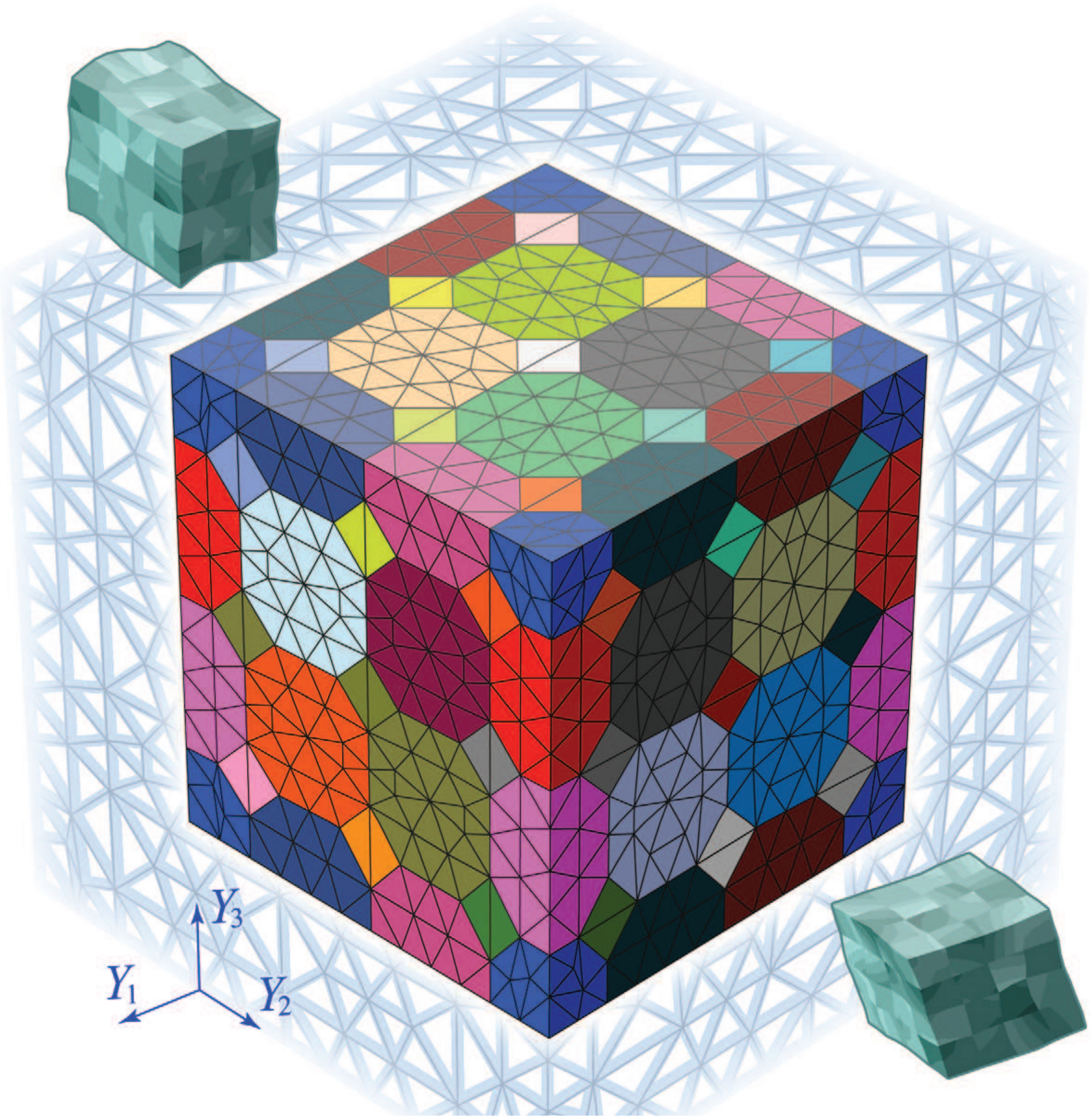
Advanced Computational Materials Modeling

From Classical to Multi-Scale Techniques



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Contents

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Preface

The systematic analysis of solid mechanics problems using numerical techniques can be traced back to the 1960s and 1970s following the development of the finite element method. The early approaches to elastic materials and, to a certain extent, inelastic problems, paved the way to an all-encompassing discipline known today as *computational materials modelling*.

As computer technologies have evolved, placing portable computers on the desk of virtually every university staff and graduate student, numerical techniques and algorithms have experienced extraordinary advances in a wide range of engineering fields. The development of new computational modelling strategies, especially those based on the finite element method, has prompted new applications such as crystal plasticity, damage and multi-scale formulations, semi-solid, particulate, porous and functionally graded materials amongst others.

This book was conceived in an attempt to congregate innovative modelling approaches so that graduate students and researchers, both from academia and industry, can use it as a springboard to further advancements. It is also important to say that this book is by no means exhaustive on the subject of materials modelling and some advanced readers would probably have appreciated the inclusion of further details on the underlying mathematical formulations. For the sake of objectivity, we have focussed on topics which show not only new and innovative modelling strategies, but also on sound physical foundations and both promising and direct application to engineering problems. Emphasis is placed on computational modelling rather than materials processing, although illustrative examples featuring some process applications are also included. A review of the state-of-the-art modelling approaches as well as a discussion on future trends and advancements is also presented by the contributors.

Finally we would like to sincerely thank all the authors for their time and commitment to produce such high quality chapters. We really appreciate their contribution.

July 2010

Miguel Vaz Jr.
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7
Modeling of Powder Forming Processes; Application of a Three-invariant Cap Plasticity and an Enriched Arbitrary Lagrangian–Eulerian FE Method

Amir R. Khoei

7.1
Introduction

Powder metallurgy is a highly developed method of manufacturing reliable ferrous and nonferrous parts. The powder metallurgy process is cost-effective, because it minimizes machining, produces good surface finish, and maintains close dimensional tolerances. The method is a material-processing technique utilized to achieve a coherent near-to-net shape industrial component. The often extremely high tolerance requirements of the parts and the cost for hard machining of a sintered component are a challenge for die pressing. One of the main difficulties that exists in the compaction-forming process of powders includes a nonhomogeneous density distribution, which has wide ranging effects on the final performance of the compacted part. The variation of density results in cracks and also in localized deformation in the compact, producing regions of high density surrounded by lower density material, leading to compact failure. The lack of homogeneity is primarily caused by friction, due to interparticle movement, as well as relative slip between powder particles and the die wall. The die geometry and the sequence of movement result in a lack of homogeneity of density distribution in a compact. Thus, the success of compaction forming depends on the ability of the process in imparting a uniform density distribution in the engineered part. In order to perform such analysis, the complex mechanisms of compaction process must be drawn into a mathematical formulation with the knowledge of material behavior.

A number of constitutive models have been developed for the compaction of powders over the last three decades, including micromechanical models [1–3], flow formulations [4], and solid mechanics models [5–11]. The porous material model, generally known as a *modified von Mises criterion* [12], has been used for the simulation of powder-forming processes. This model includes the influence of the hydrostatic stress component, and satisfies the symmetry and convexity conditions required for the development of a plasticity theory. The yielding of porous materials is more complicated than that of fully dense materials, because the onset of yielding is influenced not only by the deviatoric stress components

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