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INTERNATIONAL CENTRE FOR MECHANICAL SCIENCES

COURSES AND LECTURES - No. 368



MECHANICS OF SOLIDS  
WITH PHASE CHANGES

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## PREFACE

*This book contains the lectures delivered at the International Centre for Mechanical Sciences, Udine, Italy, in the session "Mechanics of Solids with Phase Changes", September 1995.*

*The increased interest in mechanics of materials has raised the motivation to organize such a session. Continuum mechanics has strongly influenced the research in classical plasticity of inhomogeneous materials and in composites and multiphase materials. However, all these materials possess one common feature: the more or less, spatially and temporally, fixed distribution of the various phases. This is, however, not the case for materials with solid-solid phase changes. The thermomechanical loading is responsible for the development of one or more new phases in a parent material. Therefore an interdisciplinary research by involving branches such as material sciences, physical chemistry and thermodynamics and continuum mechanics has proved to be necessary to understand the transformation behavior and the corresponding thermomechanical deformation behavior of such phase changing materials. This matter makes the research more difficult, but also more exciting. To the opinion of the authors, no current books exist that present solid-solid phase transformations in elastic and elastic-plastic materials in the light of mechanics of materials and describe the tools how to understand solid-solid phase transformations.*

*Therefore, the editors assume that this book will close a certain gap.*

*The book may be of use for both material scientists and people working in continuum mechanics. The editors tried hard to keep the presentation of the contents on such a mathematical level that post-graduate students and also practitioners with an interest in mechanics of materials can use this book as a source of better understanding as well as a tool for further development. In addition, we expect that researchers in the field of phase change phenomena may find some new information and hints for problem solutions.*

*The book is mainly devoted to diffusive and displacive phase transformations with and without plastic behavior of the parent and product phases. Mainly metals, both non ferrous and ferrous alloys are dealt with. Additionally an interesting introduction of phase change mechanics into geological problems is included.*

*Thermoelastic materials like shape memory alloys are treated both with respect to experiments and to mechanics of materials related aspects. Practical applications of theoretical concepts how to control the phase transformation and, therefore, the thermomechanical behavior of the phases are outlined. The*

*phenomenon of transformation induced plasticity (TRIP) as an enhanced plastic deformation of phase changing materials is dealt with in detail mainly for ferrous alloys under diffusive and displacive (martensitic) phase transformations.*

*The first two chapters supply an introduction to phase change phenomena and classical thermodynamics within the framework of physical metallurgy and solid state physics. The third chapter presents an overview on the displacive (martensitic) transformation with and without plasticity. An overview on the experimental work of the last decades forms an important part of this chapter. The following chapter is outlined in the same way; however, it deals with the diffusive transformation in solids. The next two chapters are mainly devoted to the modelling and simulation of the deformation behavior of shape memory alloys and ferrous alloys. Both micromechanical and numerical concepts are introduced and tested in various experiments. The concept of simulation may be used also with respect to material design if one thinks of low alloyed TRIP - Steel or shape memory alloys designed for several specific purposes.*

*Chapter 7 reports on a geological application and shows how non hydrostatic thermodynamics in conjunction with continuum mechanics may help to understand geological phenomena like wet compacting sediments.*

*The last block of three chapters is devoted to some examples of the exploitation of solid-solid phase changes like the heat treatment of metals or the design of smart structures from shape memory alloys.*

*Finally it is hoped that the reader will gain an overview on phase change phenomena from elementary physics via experiments and continuum mechanical formulations to applications of concepts in technical fields.*

*The editors are deeply indebted to the CISM Staff for all organization facilities, in particular to Prof. S. Kaliszky who represents the scientific committee and to Prof. C. Tasso for his patience as the CISM Editor.*

*M. Berveiller  
F. D. Fischer*

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