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Editors

Failure and Damage Analysis of Advanced Materials

Springer

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PREFACE

Failure as a limit state of the material behavior is well known from engineering practice. Different types of failure can be identified: transition from the elastic to plastic state, loss of stiffness, loss of fracture resistance at different scale levels, ultimate strength, and fatigue. In addition, failure can be accompanied by various types of damage. The course was discussed basic concepts and new developments in failure and damage analysis with focus on advanced materials such as composites, laminates, sandwiches and foams, and also new metallic materials. Starting from some mathematical foundations (limit surfaces, symmetry considerations, invariants) new experimental results and their analysis will be presented. Finally, new concepts for failure prediction and analysis were introduced and discussed.

The classical strength criteria developed intensively in the 19th and 20th century are mostly based on the comparison of the stress state (usually three-dimensional) with some scalar-valued properties estimated in tests. Such a phenomenological approach can be easily extended to other types of limit states of a material (for example, plastic behavior, and damage or fracture toughness). But even in the case of classical, but anisotropic structural materials, predictions are not always satisfactory and the effort required for their experimental confirmation can increase dramatically. Furthermore, in the case of advanced materials additional effects such as load dependent material response should be taken into account. These effects can induce mechanisms leading to different behavior in tension and compression.

Considering advanced metallic and non-metallic materials new methods of failure and damage prediction were discussed. Based on experimental results the traditional methods will be revised. In some cases it is enough to extend the classical approaches (for example, for metallic sheet material). In other situations (foams, composites) this is not satisfying since the different mechanisms cannot be adequately presented.

The lecture notes contains 5 parts. Part 1 (Classical and Non-Classical Failure Criteria) was prepared by Holm Altenbach & Vladimir Kolupaev. The following items are discussed: examples of failure behavior, theory of invariants and symmetry, classical isotropic models, compressibility and incompressibility, non-classical , and anisotropic *models. Part 2 (Constitutive Description of Isotropic and Anisotropic Plasticity for Metals) is written by Frédéric Barlat & Myoung-Gyu Lee and contains: modeling of advanced metallic materials, plasticity in metallic materials, isotropic and anisotropic yield criteria, state variable evolution and hardening, influence of constitutive description on failure prediction. Liviu Marsavina presented in his Part 3 (Failure and Damage in Cellular Materials): behavior of cellular materials in compression and tensile, fracture toughness of cellular materials under static and dynamic loading, effect of density, forming direction, loading speed and size effect, predicting properties of cellular materials using micromechanical models, comparison between polymer and metallic foams behavior. Neil McCartney (Part 4: Analytical Methods of Predicting Performance of Composite Materials) presents: predicting properties of undamaged lamina, predicting properties of undamaged laminates, principles controlling fracture processes in composites, prediction of ply cracking in general symmetric laminates, prediction of ply cracking in laminates subject to loading that includes bend deformation, some other important issues. Ramesh Talreja (Part 5: Analysis of Failure in Composite Structures) discusses the following problems: clarification of strength, fracture and damage in heterogeneous solids, role of constraint in lamina failure, homogenization and representative volume element concepts, continuum damage and internal variables, damage modes, thermodynamics framework for composite response with damage, damage evolution, synergistic damage mechanics. During the course were presented 6 lectures by Tomasz Sadowski on damage and failure criteria for micromechanical modeling of multiphase polycrystalline composites and joints of different materials, multiscale approach in material modeling, deformation damage theory defects initiation and propagation, experimental verification of damage and failure criteria in complex materials, modeling of hybrid joints of structural parts degradation with application of cohesive zone model. The lectures were not published by health reasons. People interested in these lectures can contact directly Tomasz Sadowski (`sadowski.t@gmail.com`).*

Last but not least we have to thank Mrs. Dr.-Ing. Anna Girchenko. She unified all manuscripts, which were finally submitted as LaTeXfiles.

Holm Altenbach and Tomasz Sadowski

CONTENTS