

Stress-strain curves for metals, ceramics and polymers

Objective

We are interested about studying and comparing stress-strain curves of metals, ceramics and polymers. Primarily, differences are due to their different chemical bonding properties (Homework 1).

Metals | Ceramics | Polymers

Metals are typically hard, opaque, shiny, and have good electrical and thermal conductivity. Generally, they are malleable (can be pressed permanently out of shape without breaking or cracking), fusible (able to be fused or melted) and ductile (able to be drawn out into a thin wire). This class of solids is also said to be mainly formed of metallic bonds. Where it is findable a "sea" of delocalized electrons that contributes for the characteristics discussed above.

On the other hand, **ceramics** have a high melting point, high hardness, poor conductivity, high moduli of elasticity (E), chemical resistance and low ductility are the norm.

Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. The first ones include biomolecules (such as DNA or proteins) and the last ones some well-known compounds: polystyrene, nylon, teflon, kevlar... Their consequently large molecular mass relative to small molecule compounds produces unique physical properties, including toughness, viscoelasticity, and a tendency to form glasses and semi crystalline structures rather than crystals.

Stress-strain Curve

Each material has a specific stress-strain curve, mainly accordingly to their stiffness and yielding point. Even different tensile tests conducted on the same material yield different results, depending upon the temperature of the specimen and the speed of the loading. Although, general diagrams can be drawn for these 3 groups of materials, as shown below.

Metals

Curve can be divide in 4 regions (Fig. 1), 03: linear portion of the curve (proportional region), where its slope corresponds to the Young's modulus. As greater is this value, stiffer is the material. Additionally, it would be possible to determine the Poisson ratio by measuring the strain in a transversal direction of the longitudinal applied stress: $\nu = -\frac{\text{Strain}_{\perp}}{\text{Strain}_{\parallel}}$. 21: material starts deforming itself in a plastic way. As soon as stress 1 is reached the ultimate strength is achieved and the *necking region* appears in the neighborhood. 14: necking region. Materials' cross section starts becoming thinner and, eventually, *rupture point* 4 is achieved and the specimen fractures. IMPORTANT: this description is about an apparent/engineering stress shown in the figure 1. Where it's assumed that the cross-sectional area remains constant. Although, this is not true! As soon as plastic deformations become relevant, cross-sectional area becomes increasingly thinner. So, the ratio of the tensile force to the true cross-sectional area at the narrowest region of the neck is bigger than considering an apparent stress.

Ceramics

Ceramics usually are brittle. Observing the diagram (Fig. 2), we verify this is significantly simpler than the previous. The main reason is that there is a very narrow plastic region. That's why the *fracture limit* (point 2) is the same as the *ultimate strength*.

Polymers

Polymers class englobes a vast number of materials w/ significantly different behaviors under stress. So, 4 main subclasses were represented. *Flexible plastics* behave similarly to metals, although w/ a greater plasticity. *Elastomers* are the ones that strains more w/ a lower stress. And finally, analogous to ceramics, are the stiff *fibers* and *rigid plastics*. With a very short elastic region but highly capable of supporting huge stresses.

Fig. 1 – Metals (Al alloy) stress-strain curve.

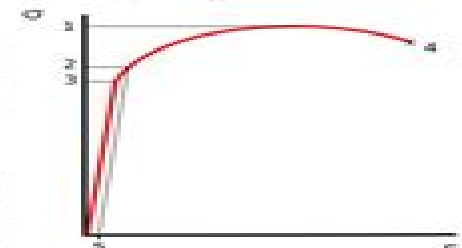


Fig. 2 - Stress-strain curve for ceramics.

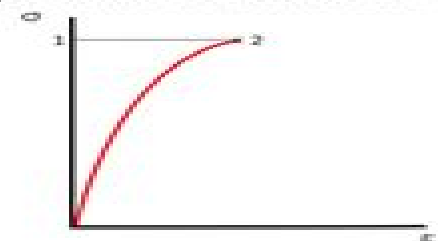
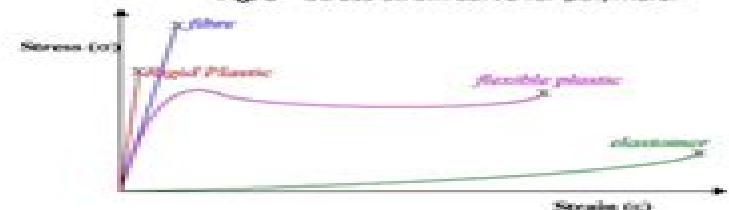


Fig. 3 – Stress-strain curve for polymers.



Stress Analysis Of Polymers

A. S. Argon



Stress Analysis Of Polymers:

Stress Analysis of Polymers James Gordon Williams, 1980 **Residual stress analysis in polymer materials using the hole drilling method - basic principles and applications** Arnaud Magnier, 2018-12-17 Stress Analysis of Polymers Williams JG., 1973 Applied Mechanics of Polymers George Youssef, 2021-12-02

Applied Mechanics of Polymers Properties Processing and Behavior provides readers with an overview of the properties mechanical behaviors and modeling techniques for accurately predicting the behaviors of polymeric materials The book starts with an introduction to polymers covering their history chemistry physics and various types and applications In addition it covers the general properties of polymers and the common processing and manufacturing processes involved with them Subsequent chapters delve into specific mechanical behaviors of polymers such as linear elasticity hyperelasticity creep viscoelasticity failure and fracture The book concludes with chapters discussing electroactive polymers hydrogels and the mechanical characterization of polymers This is a useful reference text that will benefit graduate students postdocs researchers and engineers in the mechanics of materials polymer science mechanical engineering and material science Additional resources related to the book can be found at polymersmechanics.com Provides examples of real world applications that demonstrate the use of models in designing polymer based components Includes access to a companion site from where readers can download FEA and MATLAB code FEA simulation files videos and other supplemental material Features end of chapter summaries with design and analysis guidelines practice problem sets based on real life situations and both analytical and computational examples to bridge academic and industrial applications *Elastic And Inelastic Stress Analysis* Irving H Shames, 1997-02-01 Presenting certain key aspects of inelastic solid mechanics centered around viscoelasticity creep viscoplasticity and plasticity this text is conveniently divided into three parts The sections focus on the fundamentals of elasticity useful constitutive laws and applications to simple structural members The book provides extended treatment of basic problems in static structural mechanics including elastic and inelastic effects It contains worked out examples and end of chapter problems to clarify concepts **Improved Finite Element Stress Analysis for Glassy Polymers** P. J. Dooling, S. Hinduja, P. Buckley, University of Manchester Institute of Science and Technology. Mechanical Engineering (M.M.T.), 1994 *Forensic Polymer Engineering* Peter Rhys Lewis, 2016-06-09 Forensic Polymer Engineering Why Polymer Products Fail in Service Second Edition presents and explains the latest forensic engineering techniques used in the investigation of failed polymer materials that are illustrated with a very large number of detailed case studies which show the different types of failure and the forensic engineering techniques used in their investigation In this updated edition new case studies have been added to include patent disputes and failed products such as spiral wound wall storage tanks lithium battery explosions water bottle failures and breast implant failures such as the PIP scandal New images demonstrating failure have been included and images from the previous edition are reproduced in color and enhanced with additional

explanatory detail With a dedicated focus on polymeric materials the book includes details on the experimental techniques that are used to characterize the materials particularly in cases of failure Finally the book has information on the fabrication of polymer devices as manufacturing flaws often play a role in failure Demonstrates the latest forensic engineering techniques used in the investigation of failed polymer components Presents detailed case studies that illustrate different types of failure in polymer components fittings and medical devices Examines the role of manufacturing in product failure with an overview of faults recognized in methods design and material selection Provides an integrated approach to polymer failures that covers everything from basic materials properties through to the experimental techniques required to study them

Introduction to Polymers The Open University,1992-01-01 Introduction to Polymers Second Edition discusses the synthesis characterization structure and mechanical properties of polymers in a single text giving approximately equal emphasis to each of these major topics It has thus been possible to show the interrelationship of the different aspects of the subject in a coherent framework The book has been written to be self contained with most equations fully derived and critically discussed It is supported by a large number of diagrams and micrographs and is fully referenced for more advanced reading Problems have been supplied at the end of each chapter so that students can test their understanding and practice the manipulation of data

Polymer Gears Sabu Thomas,Miroslav Huskić,Hanna J. Maria,Jože Tavčar,2024-11-16 Polymer Gears discusses polymer gear design and their efficient mechanical properties light weight and low noise during operation As plastic gears are replacing metallic gears in traditional and new applications there is still lack of material characterization and complex relations between different geometric and operating parameters Thus polymer gear design remains an open challenge This book serves as a comprehensive and professional guide on the topic providing readers with current developments carried out in the field of plastic gears production characterization and applications This will include material development tribological properties simulations and processing methods Current developments carried out in the field of plastic gear production Presents the characterization of plastic gear production Includes applications of plastic gear production and development Provides updates on tribological properties simulations and processing methods

The Physics of Deformation and Fracture of Polymers A. S. Argon,2013-03-07 Demonstrating through examples this book presents a mechanism based perspective on the broad range of deformation and fracture response of solid polymers It draws on the results of probing experiments and considers the similar mechanical responses of amorphous metals and inorganic compounds to develop advanced methodology for generating more precise forms of modelling This in turn provides a better fundamental understanding of deformation and fracture phenomena in solid polymers Such mechanism based constitutive response forms have far reaching application potential in the prediction of structural responses and in tailoring special microstructures for tough behaviour Moreover they can guide the development of computational codes for deformation processing of polymers at any level Applications are wide ranging from large strain industrial deformation texturing to

production of precision micro fluidic devices making this book of interest to both advanced graduate students and to practising professionals **Structural and Residual Stress Analysis by Nondestructive Methods** V. Hauk,1997-11-10

The field of stress analysis has gained its momentum from the widespread applications in industry and technology and has now become an important part of materials science Various destructive as well as nondestructive methods have been developed for the determination of stresses This timely book provides a comprehensive review of the nondestructive techniques for strain evaluation written by experts in their respective fields The main part of the book deals with X ray stress analysis XSA focussing on measurement and evaluation methods which can help to solve the problems of today the numerous applications of metallic polymeric and ceramic materials as well as of thin film substrate composites and of advanced microcomponents Furthermore it contains data results hints and recommendations that are valuable to laboratories for the certification and accreditation of their stress analysis Stress analysis is an active field in which many questions remain unsettled Accordingly unsolved problems and conflicting results are discussed as well The assessment of the experimentally determined residual and structural stress states on the static and dynamic behavior of materials and components is handled in a separate chapter Students and engineers of materials science and scientists working in laboratories and industries will find this book invaluable **Williams Stress Analysis of *polymers* 2ed (revise D)** J. G. WILLIAMS,1980-08-27

Polymers and Polymer Composites in Construction Leonard Hollaway,1990 Very Good No Highlights or Markup all pages are intact **Stress Analysis PF Polymers** James Gordon Williams,1980 Polymers Physical Properties ,1980-04-16

Polymers Physical Properties **Polymer Engineering Science and Viscoelasticity** Hal F. Brinson,L. Catherine Brinson,2015-01-24 This book provides a unified mechanics and materials perspective on polymers both the mathematics of viscoelasticity theory as well as the physical mechanisms behind polymer deformation processes Introductory material on fundamental mechanics is included to provide a continuous baseline for readers from all disciplines Introductory material on the chemical and molecular basis of polymers is also included which is essential to the understanding of the thermomechanical response This self contained text covers the viscoelastic characterization of polymers including constitutive modeling experimental methods thermal response and stress and failure analysis Example problems are provided within the text as well as at the end of each chapter New to this edition One new chapter on the use of nano material inclusions for structural polymer applications and applications such as fiber reinforced polymers and adhesively bonded structures Brings up to date polymer production and sales data and equipment and procedures for evaluating polymer characterization and classification The work serves as a comprehensive reference for advanced seniors seeking graduate level courses first and second year graduate students and practicing engineers **Handbook Of Polymer Tribology** Sujeet K Sinha,2018-03-07 This handbook is a collection of authoritative information in the new and expanding field of polymer tribology It brings together various research topics in the field of polymer tribology in a single volume and provides relevant

data in polymer tribology for research and industrial applications The book s chapters are written by active world renowned researchers in the field Subjects covered in this book range from the fundamentals of polymer tribology to highly applied topics such as machine element design bearing and gears hip prosthetic and microsystems applications Readers in the field of tribology in general and polymer tribology in particular will find it very useful as it covers nearly all aspects of polymer tribology Academics creating new courses based on polymer tribology will also find this book s comprehensive coverage valuable Researchers will find this book a ready source of the state of the art in the field of polymer tribology PRO 9: 2nd International RILEM Symposium on Adhesion between Polymers and Concrete - ISAPP'99 Yoshihiko Ohama,Moshe Puterman,1999 Dynamic Mechanical and Creep-Recovery Behavior of Polymer-Based Composites Akarsh Verma,Naman Jain,Sanjay M. R,Danuta Matykiewicz,Suchart Siengchin,2024-01-11 Dynamic Mechanical and Creep Recovery Behaviour of Polymer Based Composites Mechanical and Mathematical Modeling covers mathematical modelling dynamic mechanical analysis and the ways in which various factors impact the creep recovery behaviour of polymer composites The effects of polymer molecular weight plasticizers cross linking agents and chemical treatment of filler material are addressed and information on thermoplastic and thermosetting polymer based composites is also covered including their various applications and the advantages and disadvantages of their use in different settings The final 2 chapters of the book cover mathematical modeling of creep recovery behavior for polymer composites and software based simulation of creep recovery in polymer composites respectively Dynamic Mechanical and Creep Recovery Behaviour of Polymer Based Composites Mechanical and Mathematical Modeling covers mathematical modelling dynamic mechanical analysis and the ways in which various factors impact the creep recovery behaviour of polymer composites The effects of polymer molecular weight plasticizers cross linking agents and chemical treatment of filler material are addressed and information on thermoplastic and thermosetting polymer based composites is also covered including their various applications and the advantages and disadvantages of their use in different settings The final 2 chapters of the book cover mathematical modeling of creep recovery behavior for polymer composites and software based simulation of creep recovery in polymer composites respectively Analyzes the dynamic mechanical and creep recovery behaviors of thermoplastic and thermosetting polymer composites in a variety of applications Features diverse mechanical mathematical models utilized to fit data collected from creep recovery studies Covers various factors that influence dynamic mechanical properties Discusses the advantages and disadvantages of using these materials in different settings **Stress Analysis of a Polymer Extrusion Die Using Finite Element Method** Ihsan Aladdin Abbud,1982

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