

GENERAL CONSIDERATIONS

Rheological testing of thermoplastic materials can be performed on both solid samples and on melts. This is important because the choice of material form and physical state is more than a matter of convenience: Product performance issues usually are related to solid samples properties; process ability issues can be correlated with polymer melt properties. In either case, since rheology is an indirect and non-unique measurement of structure, the application of rheology to solving processing and product performance problems often reduces to comparative analysis of good and poor performing samples.

Thermoplastic solids are tested using Mechanical Spectroscopy to study polymer morphology and structure and relate these to end-use performance. Accurate solid state measurements of the material's glass transition temperature (T_g), modulus (G') and damping ($\tan \delta$) are used to predict practical use temperatures, impact properties, energy dissipation, stiffness and many other performance properties. (Dynamic mechanical testing is considered the most sensitive method for measuring the glass transition and secondary transitions of polymers.)

Moreover, rheological properties can be measured continuously as the material undergoes temperature-induced changes from amorphous to crystalline; solid to molten and vice versa. Rheological tests on thermoplastic melts measure material's flow properties and provide vital information about polymer processing.

Viscosity and Elasticity

Melts are non-Newtonian fluids and their viscosity decreases with increasing shear rate. Oscillation measurements over a range of frequencies can be used to gauge the rate of the viscosity changes with shear rate (Cox-Merz¹). This is important from the standpoint of processing ease, and for determining processing energy needs. The dynamic measurement also provides a simultaneous measure of melt elasticity, the main determinant of viscoelastic melt behavior, and the cause of such phenomena as die swell.

Low shear

Low shear rate measurements in the melt's linear viscoelastic region are a key in material solving. While thermoplastic polymer processing operations such as extrusion and injection molding typically involve high shear rates, finished part quality is often controlled by the low

shear rate behavior. For example, gauge variation can be caused by variable post-extrusion die swell, and warpage can occur from non-uniform relaxation during cooling of an improperly formulated injection molding compound. Also, by testing at low enough shear rates so that the measurements are in the melt's linear viscoelastic region, the data can be linked directly to the polymer's molecular structure such as molecular weight and molecular weight distribution factors which control polymer process ability and product performance.

Time dependence and Deborah number

Thermoplastic polymers are viscoelastic materials and as such exhibit a pronounced time or frequency dependence. For convenience, thermoplastic melts are characterized with a representative material relaxation time. In a similar way, individual steps in a manufacturing or transformation process can be described by a characteristic process time (see Figure 1).

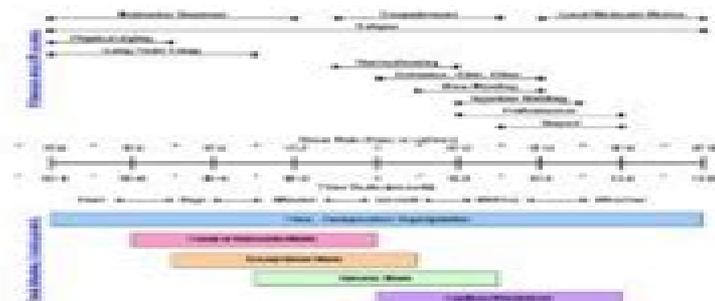


Figure 1: Process and material time

The ratio of both, the De (Deborah) number is an important process parameter. Increasing the take up speed in a film blowing process is identical to decreasing the process time; in order for the Deborah number characteristic for the process, to be constant, the material time has to be modified, typically by reducing the viscosity (decreasing the temperature or the molecular weight). Not adapting the characteristic materials time would cause the material to behave more solid-like (high De number) under the new processing regime and

¹ Cox, W.P.; Merz, E.H. J Polym Sci. 28, 118 (1958)

Understanding Rheology Of Thermoplastic Polymers

F. N. Cogswell



Understanding Rheology Of Thermoplastic Polymers:

Multiscale Characterization of Biological Systems Vikas Tomar, Tao Qu, Devendra K. Dubey, Devendra Verma, Yang Zhang, 2015-11-30 This book covers the latest research work done in the area of interface mechanics of collagen and chitin based biomaterials along with various techniques that can be used to understand mechanics of biological systems and materials Topics covered include Raman spectroscopy of biological systems scale dependence of the mechanical properties and microstructure of crustaceans thin films as biomimetic materials as well as the role of molecular level modeling The use of nanomechanics to investigate interface thermomechanics of collagen and chitin based biomaterials is also covered in detail This book also Details spectroscopy experiments as well as nanomechanic experiments Reviews exhaustively phenomenological models and Raman spectroscopy of biological systems Covers the latest in multiscaling for molecular models to predict lab scale sample properties and investigates interface thermomechanics

Mechanics of Biological Systems and Materials, Volume 6 Srinivasan Arjun Tekalur, Pablo Zavattieri, Chad S. Korach, 2015-08-07 5th International Symposium on the Mechanics of Biological Systems and Materials Volume 6 of the Proceedings of the 2015 SEM Annual Conference Exposition on Experimental and Applied Mechanics the sixth volume of nine from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on a wide range of areas including Soft Tissues Mechanics Bio Engineering and Biomechanics Natural Materials Bio Inspiration Novel Techniques and Experiments in Biomechanics Tissue Engineering Cells Mechanics

Polymers from Fossil and Renewable Resources Francesco Ciardelli, Monica Bertoldo, Simona Bronco, Elisa Passaglia, 2019-07-29 The book describes the development and commercialization of materials with viscoelastic properties placing particular emphasis on the scientific and technological differences between plastics and bioplastics The authors explain how to handle each of the two types of materials and determine the comparative environmental impact of the material life cycle The practical values of the overlapping aspects of the two types of materials from technical properties to eco compatibility are also discussed

Thermoplastic Melt Rheology and Processing Aroon Shenoy, 1996-08-23 Presents rheological data on a number of polymers making use of the master curve approach to determine unified curves for each generic type of polymer The text offers a step by step procedure for developing a spreadsheet computer program to obtain accurate thermoplastic rheograms at any temperature without using sophisticated rheometers It includes

Resorbable Polymers for Bioimplants and Fixation Devices Arbind Prasad, Vimal Katiyar, 2015-10-18 This book covers the latest research and relevant case studies about emerging resorbable materials their synthesis characterization and applications in various domains It explores the applications of resorbable composites in bone implants drug delivery systems wound healing hydrogels biomaterials for bone fracture fixations and other medical implants It also highlights the advantages associated with bioresorbable composites such as ease of modification of the chemical physical surface and biomimetic properties of polymers which makes them a

preferred composite over many other options This book will be of interest to researchers scientists and industry professionals working in the areas of material science biomedical engineering pharma health care and allied fields [Large Format Additive Manufacturing](#) Daniel Moreno Nieto, Daniel Moreno Sánchez, Ahmed A. Hassen, Eric MacDonald, Sergio I. Molina Rubio, 2026-03-09 Comprehensive reference on the technology of large format additive manufacturing Additive manufacturing AM has been adopted by several industries for high and low volume fabrication of three dimensional workpieces such as machine parts tools and specialized engineering components Depending on the desired result additive manufacturing technologies can be employed using base materials such as polymers metals or clays and cements The recent technology progress also allows for the energy material and time efficient fabrication of large format workpieces and intermediate products from the centimeter to the meter range Large Format Additive Manufacturing reviews the fabrication relevant aspects of large format additive manufacturing with polymeric cement and clay as well as metallic materials covering the technologies the specifics of the employed materials most prevalent applications and the characterization and the implementation in large scale industrial processes The book is divided into three main sections each dedicated to a material family with additional chapters addressing the specific nature of each family In Large Format Additive Manufacturing readers find First hand insights to develop cost and material efficient production of mass customized goods Clear guidance on how to transfer findings from the lab into industrial production processes Information on material characterization simulation approaches and economic drivers Case studies providing a broad and updated view of the field from experts across various disciplines Showing a clear path towards large scale precision manufacturing of intermediate and finished engineering products Large Format Additive Manufacturing is an essential up to date reference for materials scientists process engineers mechanical engineers professionals in the metal processing industry and research centers and companies interested in exploring this exciting field [Rheology and Processing of Polymeric Materials: Volume 1: Polymer Rheology](#) Chang Dae Han, 2007 Volume 1 presents first fundamental principles of the rheology of polymeric fluid including kinematics and stresses of a deformable body the continuum theory for the viscoelasticity of flexible homogeneous polymeric liquids the molecular theory for the viscoelasticity of flexible homogeneous polymeric liquids and the experimental methods for the measurement of the rheological properties of polymeric liquids The materials presented are intended to set a stage for the subsequent chapters by introducing the basic concepts and principles of rheology from both phenomenological and molecular perspectives of structurally simple flexible and homogeneous polymeric liquids Next this volume presents the rheological behavior of structurally complex polymeric materials including miscible polymer blends block copolymers liquid crystalline polymers thermoplastic polyurethanes immiscible polymer blends particulate filled polymers organoclay nanocomposites molten polymers with dissolved gas and thermostats **Introduction to Polymer Rheology and Processing** Nicholas P. Cheremisinoff, 2018-01-18 An Introduction to Polymer Rheology and Processing is a practical desk

reference providing an overview of operating principles data interpretation and qualitative explanation of the importance and relationship of rheology to polymer processing operations It covers full scale processing operations relating industrial processing operations and design methodology to laboratory scale testing Hundreds of design formulas applicable to scaling up the processing behavior of polymeric melts are presented The book also provides a working knowledge description of major rheological test methods useful in product development and includes a useful glossary of polymer and test method instrumentation definitions Lavishly illustrated and featuring numerous sample calculations and modeling approaches An Introduction to Polymer Rheology and Processing is a must have book for polymer engineers and rheologists Rheological Fundamentals of Polymer Processing J.A. Covas,J.F. Agassant,A.C. Diogo,J. Vlachopoulos,K. Walters,2013-04-17 Experts in rheology and polymer processing present up to date fundamental and applied information on the rheological properties of polymers in particular those relevant to processing contributing to the physical understanding and the mathematical modelling of polymer processing sequences Basic concepts of non Newtonian fluid mechanics micro rheological modelling and constitutive modelling are reviewed and rheological measurements are described Topics with practical relevance are debated such as linear viscoelasticity converging and diverging flows and the rheology of multiphase systems Approximation methods are discussed for the computer modelling of polymer melt flow Subsequently polymer processing technologies are studied from both simulation and engineering perspectives Mixing crystallization and reactive processing aspects are also included Audience An integrated and complete view of polymer processing and rheology important to institutions and individuals engaged in the characterisation testing compounding modification and processing of polymeric materials Can also support academic polymer processing engineering programs **Thermoplastic Polymer Additives** John T. Lutz,1989

Polymers from Agricultural Coproducts Marshall L. Fishman,American Chemical Society. Meeting,1994 Discusses the production of polymers from sustainable and renewable agricultural resources Includes overviews discussing the rationale and economic prospects for producing various polymers from agricultural materials and the status of the technology used to produce degradable polymers Reviews the characterization synthesis modification and isolation of specific groups of polymers and polymeric materials including starches starch blends composites other polysaccharides oligosaccharides monosaccharides polyamides proteins polyesters and rubbers **Polymer Rheology** R.S. Lenk,2012-12-06 Everything flows so rheology is a universal science Even if we set aside claims of such width there can be no doubt of its importance in polymers It joins with chemistry in the polymerisation step but polymer engineering is supreme in all the succeeding steps This is the area concerned with the fabrication of the polymer into articles or components with their design to meet the needs in service and with the long and short term performance of the article or component This is a typical area of professional engineering activity but one as yet without its proper complement of professional engineers An understanding of polymer rheology is the key to effective design and material plus process selection to efficient fabrication and to satisfactory service

yet few engineers make adequate use of what is known and understood in polymer rheology Its importance in the flow processes of fabrication is obvious Less obvious but equally important are the rheological phenomena which determine the in service performance There is a gap between the polymer rheologist and the polymer engineer which is damaging to both parties and which contributes to a less than satisfactory use of polymers in our society It is important that this gap be filled and this book makes an attempt to do so It presents an outline of what is known in a concise and logical fashion It does this starting from first principles and with the minimum use of complex mathematics

Macromolecules, Volume 3
Hans-Georg Elias,2005 Providing a broad survey of the entire field Macromolecules integrates representations of chemistry physics and technology as well as including precise descriptions of basic phenomena and balanced treatments of facts and theory

Papers Presented at the ... Meeting American Chemical Society. Division of Polymer Chemistry,1980 Polymer Melt Rheology F. N. Cogswell,1981 Polymer and Composite Rheology, Second Edition, Rakesh K. Gupta,2000-06-14 An analysis of polymer and composite rheology This second edition covers flow properties of thermoplastic and thermoset polymers and general principles and applications of all phases of polymer rheology with new chapters on the rheology of particulate and fibre composites It also includes new and expanded detail on polymer blends and emulsions foams reacting systems and flow through porous media as well as composite processing operations

Science Base for Materials Processing National Research Council (U.S.). National Materials Advisory Board. Committee on Science Base for Materials Processing,1979 Investigation of Non-linear Flows in Polymer Mixing Using the Boundry Integral Method Bruce Allen Davis,1995 Polymer and Composite Rheology Rakesh K. Gupta,2000-06-14 An analysis of polymer and composite rheology This second edition covers flow properties of thermoplastic and thermoset polymers and general principles and applications of all phases of polymer rheology with new chapters on the rheology of particulate and fibre composites It also includes new and expanded detail on polymer blends and emulsions

Rheology and Processing of Polymeric Materials
Chang Dae Han,2007-06-04 Volume 2 presents the fundamental principles related to polymer processign operations including the processing of thermoplastic polymers and thermosets The objective of this volume is not to provide recipies that necessarily guarantee better product quality Rather emphasis is placed on presenting a fundamental approach to effectively analyze processing operations The specific polymer processing operations for thermoplastics include plasticating single screw extrusion morphology evolution during compounding of polymer blends compatibilization of immiscible polymer blends wire coating extrusion fiber spinning tubular film blowing coextrusion and thermoplastic foam extrusion The specific polymer processing operations for thermosets include reaction injection molding pultrusion of fiber reinforced thermosets and compression molding of thermoset composites

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