Microcellular Injection Molding

This book presents the most important aspects of microcellular injection molding with applications for science and industry. The book includes: experimental rheology and pressure-volume-temperature (PVT) data for different gas materials at real injection molding conditions, new mathematical models, micrographs of rheological and thermodynamic phenomena, and the morphologies of microcellular foam made by injection molding. Further, the author proposes two stages of processing for microcellular injection molding, along with a methodology of systematic analysis for process optimization. This gives critical guidelines for quality and quantity analyses for processing and equipment design.
Microcellular Injection MoldingJohn Wiley & Sons
Eliminate the guesswork from critical mold aspects such as gate location, shape and size. And discover how to establish proper venting so you can prepare ideal mold venting - before the first shot is made. Both newcomers and experienced practitioners in the area of thermoplastics will benefit from its concise explanations of the methods and equipment used, the components necessary for smart mold design, a checklist for designing a mold, and the variety of finishes and textures available and how they are applied.
Special Injection Molding Techniques covers several techniques used to create multicomponent products, hollow areas, and hard-soft combinations that cannot be produced with standard injection molding processes. It also includes information on the processing techniques of special materials, including foaming agents, bio-based materials, and thermosets. The book describes the most industrially relevant special injection molding techniques, with a detailed focus on

understanding the basics of each technique and its main mechanisms, i.e., temperature, mold filling, bonding, residual stresses, and material behavior, also providing an explanation of process routes and their variants, and discussions of the most influencing process parameters. As special molding technologies have the potential to transform plastics processing to a highly-efficient, integrated type of manufacturing, this book provides a timely survey of these technologies, putting them into context, accentuating new opportunities, and giving relevant information on processing. Provides information about the basics needed for understanding several special injection molding techniques, including flow phenomena, bonding mechanisms, and thermal behavior Covers the basics of each technique and its main mechanisms, i.e., temperature, mold filling, bonding, residual stresses, and material behavior Discusses the most relevant processing parameters for each injection molding technique Presents a variety of techniques, including gas and water assisted injection molding, multi component injection molding, hybrid injection molding, injection molding of bio-based materials, and techniques for thermoset

This sixth international conference dedicated to the critical role of blowing agents in foamed plastics and rubber aimed to present an insight into the latest industrial progress and research for foam generation. The conference offered a comprehensive review of recent academic developments, results and future possibilities, foaming agents and blowing gases and foam processes such as microcellular technology, direct gassing processes and related gases.

Polyolefin Foams are a relatively recent development compared to the other types of foam. Topics covered in this review include: processing and the properties required for successful foam production, the molecular structures necessary, the mechanical and thermal properties and how these can be used to best advantage, markets and applications. The review is accompanied by around 400 abstracts from the Polymer Library database.

This book is composed of different chapters which are related to the subject of injection molding and written by leading international academic experts in the field. It contains introduction on polymer PVT measurements and two main application areas of polymer PVT data in injection molding, optimization for injection molding process, Powder Injection Molding which comprises Ceramic Injection Molding and Metal Injection Molding, ans some special techniques or applications in injection molding. It provides some clear presentation of injection molding process and equipment to direct people in plastics manufacturing to solve problems and avoid costly errors. With useful, fundamental information for knowing and optimizing the injection molding operation, the readers could gain some working knowledge of the injection molding.

This book focuses on plastics process analysis, instrumentation for modern manufacturing in the plastics industry. Process analysis is the starting point since plastics processing is different from processing of metals, ceramics, and other materials. Plastics materials show unique behavior in terms of heat transfer, fluid flow, viscoelastic behavior, and a dependence of the previous time, temperature and shear history which determines how the material responds during processing and its end use. Many of the manufacturing processes are continuous or cyclical in nature. The systems are flow systems in which the process variables, such as time,

temperature, position, melt and hydraulic pressure, must be controlled to achieve a satisfactory product which is typically specified by critical dimensions and physical properties which vary with the processing conditions. Instrumentation has to be selected so that it survives the harsh manufacturing environment of high pressures, temperatures and shear rates, and yet it has to have a fast response to measure the process dynamics. At many times the measurements have to be in a non-contact mode so as not to disturb the melt or the finished product. Plastics resins are reactive systems. The resins will degrade if the process conditions are not controlled. Analysis of the process allows one to strategize how to minimize degradation and optimize end-use properties.
This book describes an effective framework for setting the right process parameters and new mold design to reduce the current plastic defects in injection molding. It presents a new approach for the optimization of injection molding process via (i) a new mold runner design which leads to 20 percent reduction in scrap rate, 2.5 percent reduction in manufacturing time, and easier ejection of injected part, (ii) a new mold gate design which leads to less plastic defects; and (iii) the introduction of a number of promising alternatives with high moldability indices. Besides presenting important developments of relevance academic research, the book also includes useful information for people working in the injection molding industry, especially in the green manufacturing field.
The present PhD thesis is framed within the Industrial Doctorate Plan promoted by the Generalitat de Catalunya and has been developed in cooperation

between the Universitat Politècnica de Catalunya-BarcelonaTech, the Centre Català del Plàstic, SEAT SA and Volkswagen AG. The research project has as main objective the characterization of microcellular plastics obtained by injection molding, motivated by a concern to reduce weight, cost and carbon footprint in automotive plastic parts. First, cylindrical bars and square plates made of Acrylonitrile-Butadiene-Styrene (ABS) and 20% Glass Fiber reinforced-Polypropylene (PP 20GF) were injection molded and foamed through the MuCell® technology. Shot volume was found as the most influencing parameter on cell structure and tensile and flexural properties. The effect of mold temperature and injection speed was secondary and not statistically significant for the mechanical performance. Tensile and flexural properties decreased almost linearly with the apparent density, whereas impact resistance was strongly reduced during foaming. Glass fibers contributed to partially overcome the loss of properties due to the reduction in density. Cells act as crack arrestors by blunting the crack tip. However, once the crack is propagating, cells acting as stress concentrators lead to a decrease in fracture toughness. Because of the low amount of blowing agent injected during the foaming process, no significant changes in the thermal properties were determined as compared to that of the solid counterpart. Simulation of the microcellular injection molding process with Moldex 3D® software and prediction models of the mechanical properties based on the apparent density and morphological characteristics provided a good approach to the experimental results.

On the other hand, the Core Back tool technology was also employed in this study. By pulling the core and increasing the final thickness of the part, the apparent density decreased but the bending stiffness was greatly enhanced. Finally, a new alternative foaming technology, called IQ Foam® and developed by Volkswagen AG, was used to produce rectangular plates and compare their properties to that of the obtained by MuCell® process. By using a minimum amount of blowing agent, foamed plastic parts through IQ Foam® obtained through this process exhibited thicker solid skins and lower cell densities, but consequently higher mechanical properties. Additional benefits such as cost-effectiveness, easy-to-use and machine-independence are also offered by this new emerging technology. Polymeric foams are sturdy yet lightweight materials with applications across a variety of industries, from packaging to aerospace. As demand for these materials increase, so does innovation in the development of new processes and products. This book captures the most dynamic advances in processes, technologies, and products related to the polymeric foam market. It describes the latest business trends including new microcellular commercialization, sustainable foam products, and nanofoams. It also discusses novel processes, new and environmentally friendly blowing agents, and the development and usage of various types of foams, including bead and polycarbonate, polypropylene, polyetherimide microcellular, and nanocellular. The book also covers flame-retardant foams, rigid foam composites, and foam sandwich composites and details applications in structural engineering, electronics, and insulation. Authored by leading experts in the field, this book minimizes the gap between research and application in this important and growing area.

A practical reference for all plastics engineers who are seeking to answer a question, solve a problem, reduce a cost, improve a design or fabrication process, or even venture into a new market. Applied Plastics Engineering Handbook covers both polymer basics – helpful to bring readers quickly up to speed if they are not familiar with a particular area of plastics processing – and recent developments – enabling practitioners to discover which options best fit their requirements. Each chapter is an authoritative source of practical advice for engineers, providing authoritative guidance from experts that will lead to cost savings and process improvements. Throughout the book, the focus is on the engineering aspects of producing and using plastics. The properties of plastics are explained along with techniques for testing, measuring, enhancing and analyzing them. Practical introductions to both core topics and new developments make this work equally valuable for newly qualified plastics engineers seeking the practical rules-of-thumb they don't teach you in school, and experienced practitioners evaluating new technologies or getting up to speed on a new field The depth and detail of the coverage of new developments enables engineers and managers to gain knowledge of, and evaluate, new technologies and materials in key growth areas such as biomaterials and nanotechnology This highly practical handbook is set apart from other references in the field, being written by engineers for an audience of engineers and providing a wealth of real-world examples, best practice guidance and rules-of-thumb

This book covers the most recent and important developments in advanced injection molding technologies, such as intelligent process control; technology innovations and computer simulation for emerging special injection molding processes like microinjection molding, microcellular injection molding, water-assisted foaming, water-assisted injection molding, and variable mold temperature technologies; conductive polymer foams and composites; injection molding of optical products; and an automated mold design navigation system with integrated knowledge management capability. It is intended to be used as a textbook for both introductory and advanced injection molding courses, as a must-have reference for professional engineers and engineering managers who want to keep abreast of the latest technological developments and applications, and in libraries to serve interested readers from both academic and industrial communities as well as the general public. With chapters written by an international team of experts, this book provides a broad and insightful coverage, complementary to other books on injection molding.

This book covers the mechanism, salient features, and important aspects of various subtractive, additive, forming and hybrid techniques to manufacture near net-shaped products. The latest research in this area as well as possible future research are also highlighted.

Microcellular Foam Injection Molding Process.

This presentation outlines the equipment requirements for processing microcellular and reinforced Reaction Injection Molding (RIM). The presentation will review the following

areas: mixing and metering equipment, mix heads, neucleation devices, molds clamps, and molds.
This practical introductory guide to injection molding simulation is aimed at both practicing engineers and students. It will help the reader to innovate and improve part design and molding processes, essential for efficient manufacturing. A user-friendly, case-study-based approach is applied, enhanced by many illustrations in full color. The book is conceptually divided into three parts: Chapters 1–5 introduce the fundamentals of injection molding, focusing the factors governing molding quality and how molding simulation methodology is developed. As they are essential to molding quality, the rheological, thermodynamic, thermal, mechanical, kinetic properties of plastics are fully elaborated in this part, as well as curing kinetics for thermoset plastics. Chapters 6–11 introduce CAE verification of design, a valuable tool for both part and mold designers toward avoiding molding problems in the design stage and to solve issues encountered in injection molding. This part covers design guidelines of part, gating, runner, and cooling channel systems. Temperature control in hot runner systems, prediction and control of warpage, and fiber orientation are also discussed. Chapters 12–17 introduce research and development in innovative molding, illustrating how CAE is applied to advanced molding techniques, including co-/bi-Injection molding, gas-/water-assisted injection molding, foam injection molding, powder injection molding, resin transfer molding, and integrated circuit packaging. The authors come from the creative simulation team at CoreTech System (Moldex3D), winner of the PPS James L. White Innovation Award 2015. Several CAE case study exercises for execution in the Moldex3D software are included to allow readers to practice what they have learned and test their understanding. This third edition has been written to thoroughly update the

coverage of injection molding in the World of Plastics. There have been changes, including extensive additions, to over 50% of the content of the second edition. Many examples are provided of processing different plastics and relating the results to critiCal factors, which range from product design to meeting performance requirements to reducing costs to zero-defect targets. Changes have not been made that concern what is basic to injection molding. However, more basic information has been added concerning present and future developments, resulting in the book being more useful for a long time to come. Detailed explanations and interpretation of individual subjects (more than 1500) are provided, using a total of 914 figures and 209 tables. Throughout the book there is extensive information on problems and solutions as well as extensive cross referencing on its many different subjects. This book represents the ENCYCLOPEDIA on IM, as is evident from its extensive and detailed text that follows from its lengthy Table of CONTENTS and INDEX with over 5200 entries. The worldwide industry encompasses many hundreds of useful plastic-related computer programs. This book lists these programs (ranging from operational training to product design to molding to marketing) and explains them briefly, but no program or series of programs can provide the details obtained and the extent of information contained in this single sourcebook.

This book covers a variety of topics related to machine manufacturing and concerning machine design, product assembly, technological aspects of production, mechatronics and production maintenance. Based on papers presented at the 6th International Scientific-Technical Conference MANUFACTURING 2019, held in Poznan, Poland on May 19-22, 2019, the different chapters reports on cutting-edge issues in constructing machine parts, mechatronic solutions and modern drives. They include new ideas and technologies for machine cutting and precise processing. Chipless technologies, such as founding, plastic forming, non-metal construction materials and composites, and additive techniques alike, are also analyzed and thoroughly discussed. All in all, the book reports on significant scientific contributions in modern manufacturing, offering a timely guide for researchers and professionals developing and/or using mechanical engineering technologies that have become indispensable for modern manufacturing.

A novel method of producing injection molded parts with a foamed micro structure has been developed. It has been named supercritical fluid-laden pellet injection molding foaming technology (SIFT). Compared with conventional microcellular injection molding (MIM) tech-nologies, SIFT lowers the equipment costs significantly without sacrificing the production rate, making it a very promising candidate for mass producing foamed injection molded parts. In this study, both nitrogen (N2) and carbon dioxide (CO2) were verified by experiments to be suitable for this process as physical blowing agents. A novel foam injection molding approach using CO2+N2 co-blowing agents was proposed in this study. It has been discovered that when CO_2 and N_2 were introduced together as co-blowing agents at appropriate ratios, foamed parts with much finer morphology can be produced using this approach compared with using either blowing agent alone. It was first realized by combining the SIFT gas-laden pellets with the microcellular injection molding (MIM), such that N_2 and CO_2 can be introduced to the foaming process independently in two steps with precise dosage control. This approach has been implemented on several types of commodity polymers with equal success including low density polyethylene (LDPE), poly??propylene (PP), high impact polystyrene (HIPS), and thermoplastic polyurethane (TPU) with two distinct mold geometries, and all lead to extraordinarily fine cell structures and/or high foam expansion ratio. To enhance the performance of the SIFT technology for future stringent industrial applications, several improvements were made. Methods to further enhance the cell nucleation rate were investigated. For the purpose of prolonging the gas-laden pellets shelf life, low molecular weight (LMW) additives were compounded with the polymer matrix. The experimental results indicate that LMW additives can effectively reduce the gas desorption rate from the pellets and lead to a longer shelf. It was found that at certain blend compositions, the ductility of the molded samples can be dramatically improved while

achieving significant weight reduction. This novel ductility enhancing mechanism was investigated in this study. The analysis indicates that to achieve improved ductility, it is important to create a microcellular structure with a sub-micron scale immiscible secondary phase.
A growing number of plastics processors gain a competitive edge by utilizing the commercial microcellular process using existing injection molding or extrusion equipment at commercial production rates with low-cost modifications. End users also gain an advantage when the microcellular process is incorporated into product design and cost. To facilitate the transition and to help processors and end users make the most of this cutting edge commercial technology, this book provides a comprehensive description of all crucial elements.
Microcellular polymer injection molding is a growing industry technique due to its ability to produce dimensionally stable stress free parts while reducing cycle time, material usage, and energy costs. The process was invented by Dr. Nam P. Suh at the Massachusetts Institute of Technology in the early 1980's. The basic idea is to dissolve a supercritical fluid into the polymer melt which will nucleate and expand within the part core after injection during the cooling stage. Microcellular polymer injection molding is becoming increasingly popular in automotive, semiconductor, and industrial

applications. While the technique has been widely successful using amorphous polymers, semi-crystalline polymers present new challenges not encountered during processing with their amorphous counterparts. The polymer chains in a semi-crystalline material develop an organized crystal structure during the cooling stage. Crystal development generates two main issues for microcellular processing. The first being that the excess heat released during the crystal formation affects the expansion of the microcellular bubble causing unpredictable non-uniform growth. The second is that the growth of the crystal structure within the polymer melt expels and displaces the supercritical fluid forcing the foaming to occur out at the edges of the part rather than uniformly through its core. This paper develops and explores strategies to control and overcome these problems. The first strategy is to effectively control the cooling rate. It is well know and has been proven, that increasing the cooling rate during the crystallization process can decrease crystallinity effectively freezing the polymer microstructure in place before the polymer chains can become completely organized. The second strategy is to utilize in mold counter pressure to observe its effect of the development of the foaming and crystallization. In mold counter pressure has been found to be an effective means of controlling bubble size and distribution during amorphous microcellular injection molding therefore it has merit for being an effective method to control foaming with semi-crystalline polymers. These two strategies have been implemented on a set of experiments and the results measured and observed by differential scanning calorimetry and scanning electron microscopy. The results of the experiment indicate the strategies implied are effective methods for improving part quality and also impose confidence in further development.

SCFs are currently the subjects of intense research and commercial interest. Applications such as the RESS (rapid expansion of supercritical fluid solutions) process are part of standard industrial practice. In view of their ever-growing importance in the polymer industry there is a need to fully comprehend how supercritical fluids interrelate with polymeric materials to realise the potential that can be gained from their use. The authors review the basic principles of SCFs and their application within the polymer industry: characteristics and properties, extraction of unwanted residual products, polymerisation solvents, and polymer impregnation. Processing applications such as plasticisation, foaming and blending are also considered. There is discussion of the potential within the polymer recycling industry for use of SCFs as cleaning agents or within supercritical oxidation processes. Around 400 references with abstracts from recent global literature accompany this review, sourced from the Polymer Library, to facilitate further reading. A subject index and a company index are included. Foaming with Supercritical Fluids, Volume Nine provides a comprehensive description of the use of supercritical fluids as blowing agents in polymer foaming. To this aim, the fundamental issues on which the proper design and control of this process are rooted are discussed in detail, with specific attention devoted to the theoretical and experimental aspects of sorption thermodynamics of a blowing agent within a polymer, the effect of the absorbed blowing agent on the thermal, interfacial and rheological properties of the expanding matter, and the phase separation of the gaseous phase, and of the related bubble nucleation and growth phenomena. Several foaming technologies based on the use of supercritical blowing agents are then described, addressing the main issues in the light of the underlying chemical-physical phenomena. Offers strong fundamentals on polymer properties important on foaming Outlines the use of supercritical fluids for foaming Covers theoretical points-of-view, including foam formation of the polymer/gas solution to the setting of the final foam Discusses the several processing technologies and applications

Applied Plastics Engineering Handbook: Processing, Materials, and Applications, Second Edition, covers both the polymer basics that are helpful to bring readers quickly up-to-speed if they are not familiar with a particular area of plastics processing and the recent developments that enable practitioners to discover which options best fit their requirements. New chapters added specifically cover polyamides, polyimides, and polyesters. Hot topics such as 3-D printing and smart plastics are also included, giving plastics engineers the information they need to take these embryonic technologies and deploy them in their own work. With the increasing demands for lightness and fuel economy in the automotive industry (not least due to CAFÉ standards), plastics will soon be used even further in vehicles. A new chapter has been added to cover the technology trends in this area, and the book has been substantially updated to reflect advancements in technology, regulations, and the commercialization of plastics in various areas. Recycling of plastics has been thoroughly revised to reflect ongoing developments in sustainability of plastics. Extrusion processing is constantly progressing, as have the elastomeric materials, fillers, and additives which are available. Throughout the book, the focus is on the engineering aspects of producing and using plastics. The properties of plastics are explained, along with techniques for testing, measuring, enhancing, and analyzing them. Practical introductions to both core topics and new developments make this work equally valuable for newly qualified plastics engineers seeking the practical rules-of-thumb they don't teach you in school and experienced practitioners evaluating new technologies or getting up-to-speed in a new field. Presents an authoritative source of practical advice for engineers, providing guidance from experts that will lead to cost savings and process improvements Ideal introduction for both new engineers and experienced practitioners entering a new field or evaluating a new technology Updated to include the latest technology, including 3D Printing, smart polymers, and thorough coverage of biopolymers and biodegradable plastics Polylactide Foams: Fundamentals, Manufacturing, and Applications provides an introduction to the fundamental science behind plastic foams, polylactic acid) and polylactide foaming, giving designers tactics to replace traditional resins with sustainable and biodegradable materials. The book then delves deeper into the technology behind PLA foaming, such as PLA/gas mixture characteristics, solubility, interfacial tension behaviors and crystallization kinetics of various types of PLA and their compounds. The foaming behaviors and mechanisms of various types of PLA and PLA compounds are extensively analyzed and discussed through different manufacturing technologies, namely extrusion foaming, foam injection molding and bead foaming. Interest in Poly(lactic acid) and PLA foams is extremely high – particularly as a potential replacement for styrenic resins – and the price of PLA resin is lower than ever before. This biopolymer has significant potential to improve the sustainability of the plastics industry. Polylactide Foams have a range of potential applications, such as in construction, packaging, insulation, biomedical scaffolds, and others. However, processing and performance of PLA are not at the same level as other non-biodegradable resins. Introduces the concepts behind foaming, poly(lactic acid) and PLA foaming Supports further research and development in PLA foams by covering the state-of-the-art in different manufacturing and processing methods Provides practical guidance for materials scientists and engineers in industry looking to replace traditional polymer resins with a sustainable, biodegradable alternative