Book Reviews

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1 Thixoforming, Semi-Solid Metal Processing

by: G. Hirt and R. Kopp
Published 2009
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61, 69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 474pp
ISBN: 978-3-527-32204-6

Semi-solid forming of metals is a fascinating technology offering the opportunity to manufacture net-shaped metal components of complex geometry in a single forming operation. At the same time, high mechanical properties can be achieved due to the unique microstructure and flow behaviour. Successful semi-solid forming processes require narrow tolerances in all process steps, including feedstock generation, reheating and the forming process. It is this strong and highly nonlinear interrelation between the parameters of each process step on the one hand and the material microstructure and flow behaviour on the other which still causes a challenge for scientific understanding and economic mass production.

This book first gives a substantial general overview of worldwide achievements of semi-solid metal (SSM) technology to date. The main part then presents latest research results concerning the material fundamentals and process technology and material and process modelling. In addition to contributions from internationally recognised scientists elsewhere, most of the results presented were obtained within the activities of the collaborative research centre SFB289, "Forming of metals in the semi-solid state and their properties", at RWTH Aachen University. This research centre was funded at RWTH form 1996 to 2007 by the Deutsche Forschungs gemeinschaft (DFG) involving nine institutes. Even though this book briefly covers the whole period, it is especially intended to make the results of the most recent activities, dating from 2004 to 2007, available as a whole to the international community.

Recent research has investigated the unique flow behaviour in semisolid state exhibited by metals and alloys. This has led to semi-solid metal forming, called this forming, which is highly relevant to the manufacture of complex near-net-shape components in the interest of increasingly sophisticated products. This has recently been demonstrated by the industrial scale production of aluminium components, and there are impressive laboratory examples for semi-solid forming of iron and steels.

Offering a sound technological overview, while also including the fundamental aspects, this book provides the knowledge needed to master the highly challenging process characteristics for successful application in industrial production. It summarises the first-hand experience gained from 12 years of collaborative research covering materials science, rheology, casting and forming, control and surface technology as well as the modelling of flow behaviour, tool engineering and systems engineering, and thus treats all the vital aspects of this field.

The book covers semi-solid forming of aluminium alloys and steels from feedstock generation to part properties and also process control and die technologies. It is intended for engineers and scientists in industry and academia who want to achieve a general overview of the technology involved and a deeper understanding of the fundamental basics of this innovative technology.

2 Fatigue Crack Propagation in Metals and Alloys, Microstructural Aspects and Modelling Concepts

by: U. Krupp
Published 2007
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61,
69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 311pp
ISBN: 978-3-527-31537-6

Crack initiation and early crack propagation are decisive elements of material fatigue in metallic materials. The behaviour on the micro-scale level in this phase greatly, its usefulness and attractiveness for specific applications. It is impossible to quantify this key phase with non-destructive testing such as ultrasonic inspection, nor are the common methods of elastic and elastic-plastic fracture mechanics applicable. Therefore, prediction possibilities and purposeful microstructure design towards improved material behaviour are highly desirable.

Theories of crack growth existed before then, of course, highly speculative and based on unrealistic models. Only after appropriate fracture mechanics parameters were developed to allow the driving forces for crack growth to be expressed for a wide variety of component geometries did predictive capability greatly improve for fatigue design purposes. The traditional approach of designing against fatigue, known as the 'total-life' approach, worked adequately on the whole before the arrival of linear elastic fracture mechanics, mainly because it was backed by extensive (and expensive) experimentation. It also has undergone improvements, for examples in counting cycles during variable load cycling and in strain (rather than stress)-based predictions, and continues in wide use today, even in certain aerospace applications where usually fracture mechanics considerations now dominate. The total-life approach can be valid in situations where inspections for cracks are difficult or are economically prohibitive. The success of fracture mechanics in applications to aircraft probably arises from the necessity to se high stresses in aircraft and where relatively infrequent very high stress cycles promote early crack initiation, even in the absence of significant manufacturing defects, on which some fracture mechanicians rely to justify the approach.

The book contains the following chapters:

- Introduction
- Basic concepts of metal fatigue and fracture in the engineering design process
- Experimental approaches to crack propagation
- Physical metallurgy of the deformation behaviour of metals and alloys

- Initiation of microcracks
- Crack propagation: microstructural aspects
- Modelling crack propagation accounting for microstructural features
- Concluding remarks

It covers the range from elementary dislocation behaviour to recent advances in modelling. It is thus suited to a wide range of students from different backgrounds and developmental stages: veterans of fatigue studies will find it interesting. In that it contains detailed treatments of microstructural effects on short crack growth behaviour, the book goes far to bridge gaps of understanding between material scientists and mechanical engineers.

3 Metallic Biomaterial Interfaces

by: J. Breme, C.J. Kirkpatrick and R. Thull
Published 2008
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61,
69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 271pp
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Materials used for the construction of implants have to fulfil mechanical, physical, chemical and biological requirements. Beside suitable mechanical properties like high fatigue strength, sufficient deformatibility and high elasticity they must have biocompatibility and corrosion resistance. The titanium materials meet these requirements best as compared to other metallic biomaterials. Owing to the ever present surface oxide layer with its beneficial thermodynamic, physical and chemical properties, titanium and its alloys are the metallic biomaterials of preference. In particular the strongly negative heat of formation of titanium and its alloys exhibit bioadhesion because of the presence of free hydroxyl groups on the oxide surface.

With a view to overcoming persisting clinical problems, the program was centred on the sustainable improvement of biomaterials for long-term implants. Most of all this requires an improvement of those material characteristics that are determined both by the site of implantation and the functional demands. Specifically, this involves the interface between the material, especially its surface, and the biosystem. The interdisciplinary research approach, with the creation of a functioning network between the various project groups, successfully promoted novel biomaterial modifications, targeted effects on the interface and also permitted subsequent biological reactions to be characterised and finally developed for the field of implantology.

In projects which were concerned with the specific characteristics of the individual phases it was essential to demonstrate that the results obtained permitted a good correlation between material properties and the reactions of the biological system.

The results of physicochemical wear and corrosion experiments also served to improve materials used in implants for load bearing applications, as did relevant studies on the biological effects of degradation products in cell systems.

With suitable surface modifications or coatings it was possible to promote desirable physicochemical properties of the bulk material and inhibit disadvantageous properties.

These modifications included a spectrum of physical, chemical as well as biological methods. In numerous cases it was possible to demonstrate a modification-specific influence of the interface on the interaction with the biosystem. However, coatings with a thickness in excess of 1 μm and aimed at separating the material from the biosystem were not part of this priority program. By contrast, the principal goals of the program focused on studies of improving biocompatibility by modulating the elastic modulus of the bulk material and by mechanical structuring of the surface in relation to the achievable biological efficiency of protein interaction with celly.

The book contains the following chapters:

- Interface influence of materials and surface modification
    - Introduction
    - Metals and alloys
    - Topological surface modifications
    - Chemical surface modifications
- Physical and physicochemical surface characterisation
    - Introduction
    - Surface topology
    - Spectroscopic interface characterisation
    - Physical characterisation of protein adsorption: time-resolved determination of protein adsorption using quartz crystal microgravimetry with dissipation monitoring (QCM-D)
    - Topology-dependent cellular interactions.

The aim of the present research project is the improvement of the implant/tissue interface. Besides the development of new abrasion-resistant titanium alloys and coatings, the main goal is an improvement of the interface by means of surface modification.

4 Functional Fillers for Plastics

by: M. Xanthos
Published 2005
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61,
69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 432pp
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It is generally accepted that growth in plastics consumption and the development of new and specialised applications are related to advances in the field of multi component, multiphase polymer systems. These include composites, blends and alloys and foams. Fillers are essential components of multiphase composite structures; they usually form the minor dispersed phase in a polymeric matrix.

Increased interest in the use of discontinuous fillers as a means to reduce the price of moulding compounds begun about 30 years ago when increasing oil prices made necessary the replacement of expensive polymers with less costly additives. When such additives had also a beneficial effect on certain mechanical properties (mostly modulus and strength) they were also known as reinforcing fillers. Since that time, there has been a considerable effort to extend the uses of existing fillers by:

- particle size and shape optimisation
- developing value-added materials through surface treatments
- developing efficient methods for their incorporation in plastics.

The term 'filler' is very broad and encompasses a very wide range of materials. We arbitrarily define in this book as fillers a variety of natural or synthetic solid particulates (inorganic, organic) that may be irregular, acicular, fibrous or flakey and are used in most cases in reasonably large volume loadings in plastics, mostly thermoplastics. Continuous fibres or ribbons are not included. Elastomers are also not included in this definition as well as many specially additives that are used at low concentrations.

This present volume is not intended to be a handbook listing individual fillers according to their generic chemical structure or name but rather a comprehensive and up-to-date presentation, in a unified fashion, of structure (property) processing relationships in thermoplastic composites containing discontinuous fillers that would help the identification of new markets and applications. For convenience, fillers are grouped according to their primary functions that include modification of:

- mechanical properties
- flame retardancy
- electrical and magnetic properties
- surface properties
- processability.

For each filler there is always a series of additional functions, Examples include degradability enhancement, bioactivity, radiation absorption, damping enhancement, enhancement of dimensional stability, reduced permeability and reduced density.

The book presents the following contents:

- *Polymers and fillers*: modification of polymer mechanical and rheological properties with functional fillers, mixing of fillers with plastics.
- Surface modifiers and coupling agents: silane coupling agents, titanate coupling agents, functional polymers and other modifiers.
- *Fillers and their functions*: glass fibres, mica flakes, nanoclays and their emerging markets, carbon nanotubes/nanofibres and carbon fibres, natural fibres, talc, kaolin, wollastonite, wood flour, calcium carbonate, fire retardants, conductive and magnetic fillers, surface property modifiers, processing aids, glass and ceramic spheres, bioactive fillers, in situ generated fillers: organic-inorganic hybrids.

For engineers, scientists and technologists involved in the industrially this work is important sector of polymer composites.

5 Block Copolymers in Nanoscience
by: M. Lazzari, G. Liu and S. Lecommandoux
Published 2006
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61, 69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 428pp
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Nanoscience and technology deal with the preparation, study, manipulation and application of nanometre-sized structures. Nanoscience and technology have the potential for revolutionising the ways in which materials and products are created and the range and nature of functionalities that can be accessed. It is an interdisciplinary area of research and development activity that has been growing explosively worldwide in the past decade.

This book gives an overview of recent developments in the nanoscience and technology of block polymers. Instead of a simple collection of review chapters, our objective was to compile a handbook that carefully evaluates all types of applications for block copolymers: as tools for fabricating other nanomaterials, as structural components in hybrid materials and nanocomposites, and as functional materials.

The book contains the following chapters:

- An introduction to block copolymer applications: State-of-the-art and future developments
- Guidelines for synthesising block copolymers
- Block copolymer vesicles
- Block copolymer micelles for drug delivery in nanoscience
- Stimuli-responsive block copolymer assemblies
- Self-assembly of linear polypeptide-based block copolymers
- Synthesis, self-assembly and applications for polyferrocenylsilane block copolymers
- Supramolecular block copolymers containing metal-ligand binding sites: From synthesis to properties
- Methods for the alignment and the large-scale ordering of block copolymer orphologies
- Block copolymer nanofibres and nanotubes
- Nanostructured carbons from block copolymers
- Block copolymers at interfaces
- Block copolymers as templates for the generation of mesostructured inorganic materials
- Mesostructured polymer-inorganic hybrid materials from blocked macromolecular architestures and nanoparticles
- Block lonomers for fuel cell application

- Structure, properties and applications of ABA and ABC triblock copolymers with hydrogenated polybutadiene blocks
- Basic understanding of phase behaviour and structure of silicone block copolymers and surfactant-block copolymer mixtures.

This book is dedicated to young research scientists who want to get into this field, and also to specialists who want to access an easy overview of the most recent developments.

Taking a detailed look at one of the key focal points where nanotechnology and block copolymers meet, this first book in the field provides both and introductory view for beginners as well as i-depth knowledge for specialists in the various research areas involved. It investigates all types of applications for block copolymers ranging from physics and chemistry to biology, medicine, and engineering. Specifically, their use is discussed as tools or templates for fabricating polymeric and hybrid nanostructures, as precursors for carbon nanostructures, and as functional materials in fuel celly, stimuli-responsive materials, in drug delivery, diagnostics, and sensoring.

All stages of block copolymer studies from synthesis, characterisation, and assembly to nanostructure fabrication and applications are covered in a multidisciplinary approach which provides vital reading to materials scientists and engineers, chemists, physicists and biologists alike.

6 Cellular and Porous Materials

by: A.Öchsner, G.E. Murch, J.S. and de Lemos
Published 2008
by Wiley-VCH Verlag GmbH & Co. KgaA, P.O. Box 10 11 61,
69451 Weinheim, Boschstrasse 12, 69469 Weinheim, Germany, 442pp
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Nature frequently uses cellular and porous materials for creating load-carrying and weight-optimised structures. Thanks to their cellular design, natural materials such as wood, cork, bones, and honeycombs fulfil structural as well as functional demands. For a long time, the development of artificial cellular materials has been aimed at utilising the outstanding properties of biological materials in technical applications. As an example, the geometry of honeycombs was identically converted into aluminium structures which have been used since the 1960s as cores of lightweight sandwich elements in the aviation and space industries. Nowadays, in particular, foams made of polymeric materials are widely used in all fields of technology. For example, Styrofoam® and hard polyurethane foams are widely used as packaging materials. Other typical application areas are the fields of heat and sound absorption. During the last few years, techniques for foaming metals and metal alloys and for manufacturing novel metallic cellular structures have been developed. Owing to their specific properties, these cellular materials have considerable potential for applications in the future. The combination of specific mechanical and physical properties distinguishes them from traditional dense metals, and applications with multifunctional requirements are of special interest in the context of such cellular metals. Their high stiffness, in conjunction with a very low specific weight, and their high gas permeability combined with a high thermal conductivity can be mentioned as examples. Cellular materials comprise a wide range of different arrangements and forms of cell structures. Metallic foams are being investigated intensively, and they can be produced with a closed- or open-cell structure. Their main characteristic is their very low density. The most common foams are made of aluminium alloys. Quite a regular arrangement of cells is obtained in structure. Their main characteristic is their very low density. The most common foams are made of aluminium alloys. Quite a regular arrangement of cells is obtained in structures, e.g., with hollow spheres. A perfect regular structure results from interconnecting networks of straight beams; materials of this type are known as lattice block materials. What all these different cellular materials have in common is that their physical properties are not only determined by their cell wall material but also significantly by their microstructure.

The book contains 12 chapters written by experts in the relevant fields from academia and from major national laboratories/research institutes. The first part of the book introduces in detail different numerical and analytical methods in order to characterise and predict the effective thermal properties. Each of these chapters focuses on a detailed introduction of the theoretical and/or experimental method(s) which are applied to the characterisation of different materials.

The second part of the book addresses various types of applications and specialised topics related to the context of thermal properties of cellular and porous materials.

Combining different physical properties, e.g., high mechanical damping together with heat insulation and relatively high specific stiffness, offers the possibility for numerous new future-oriented applications in the automotive, aerospace and other industries.

The book contains issues given in chapters:

- Interfacial heat transport in highly permeable media: a finite volume approach
- Effective thermal properties of hollow-sphere-structures: a finite element approach
- Thermal properties of composite materials and porous media: lattice-based Monte Carlo approaches
- Fluid dynamics in porous media: a boundary element approach
- Analytical methods for heat conduction in composites and porous media
- Modelling of composite heat transfer in open-cellular porous materials at high temperatures
- Thermal conduction through porous systems
- Thermal property of lotus-type porous copper and application to heat sinks
- Thermal characterisation of open-celled metal foams by direct simulation
- Heat transfer in open-cell metal foams subjected to oscillating flow
- Radiative and conductive thermal properties of foams
- On the application of optimisation techniques to heat transfer in cellular materials.

The book is essential reading for solid state chemists, materials scientists, physicists, surface chemists, and others.