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Additive Manufacturing Handbook
Report of the Workshop Predictive Theoretical, Computational and Experimental Approaches for Additive Manufacturing (WAM 2016)
Topology Optimization in Structural Mechanics
Topology Optimization in Engineering Structure Design
Precision Metal Additive Manufacturing
Metal Additive Manufacturing
Topology Optimisation in Additive Manufacturing
Advances in Metal Additive Manufacturing
Additive Manufacturing, Second Edition
Towards Design Automation for Additive Manufacturing
Metal Additive Manufacturing
Revolutionizing Aircraft Materials and Processes

Springer Handbook of Additive Manufacturing
Additive Manufacturing

JAX JACOB

A Guide to Additive Manufacturing Springer Nature
The field of additive manufacturing is growing dynamically as the interest is persisting from manufacturing sector, including other sectors as well. Conceptually, additive manufacturing is a way to build parts without using any part-specific tooling or dies from the computer-aided design (CAD) file of the part. Second edition of Additive Manufacturing highlights the latest advancements in the field, taking an application oriented approach. It includes new material on traditional polymer based rapid prototyping technologies, additive manufacturing of metals and alloys including related design issues. Each chapter comes with suggested reading, questions for instructors and PowerPoint slides.
Topology Design Methods for Structural Optimization CRC Press
In recent decades, the development of computer-controlled manufacturing by adding materiallayer by layer, called Additive Manufacturing (AM), has developed at a rapid pace. The technologyadds possibilities to the manufacturing of geometries that are not possible, or at leastnot economically feasible, to manufacture by more conventional manufacturing methods. AMcomes with the idea that complexity is free, meaning that complex geometries are as expensiveto manufacture as simple geometries. This is partly true, but there remain several design rulesthat needs to be considered before manufacturing. The research field Design for Additive Manufacturing(DfAM) consists of research that aims to take advantage of the possibilities of AMwhile considering the limitations of the technique. Computer Aided technologies (CAx) is the name of the usage of methods and software thataim to support a digital product development process. CAx includes software and methodsfor design, the evaluation of designs, manufacturing support, and other things. The commongoal with all CAx disciplines is to achieve better products at a lower cost and with a shorterdevelopment time. The work presented in this thesis bridges DfAM with CAx with the aim of achieving designautomation for AM. The work reviews the current DfAM process and proposes a new integratedDfAM process that considers the functionality and manufacturing of components. Selectedparts of the proposed process are implemented in a case study in order to evaluate theproposed process. In addition, a tool that supports part of the design process is developed. The proposed design process implements Multidisciplinary Design Optimization (MDO) witha parametric CAD model that is evaluated from functional and manufacturing perspectives. Inthe implementation, a structural component is designed using the MDO framework, which

includesComputer Aided Engineering (CAE) models for structural evaluation, the calculation ofweight, and how much support material that needs to be added during manufacturing. Thecomponent is optimized for the reduction of weight and minimization of support material,while the stress levels in the component are constrained. The developed tool uses methodsfor high level Parametric CAD modelling to simplify the creation of parametric CAD modelsbased on Topology Optimization (TO) results. The work concludes that the implementation of CAx technologies in the DfAM process enablesa more automated design process with less manual design iterations than traditional DfAM processes.It also discusses and presents directions for further research to achieve a fully automateddesign process for Additive Manufacturing.

Advances in Additive Manufacturing and Metal Joining Springer Nature

This book provides a wealth of practical guidance on how to design parts to gain the maximum benefit from what additive manufacturing (AM) can offer. It begins by describing the main AM technologies and their respective advantages and disadvantages. It then examines strategic considerations in the context of designing for additive manufacturing (DfAM), such as designing to avoid anisotropy, designing to minimize print time, and post-processing, before discussing the economics of AM. The following chapters dive deeper into computational tools for design analysis and the optimization of AM parts, part consolidation, and tooling applications. They are followed by an in-depth chapter on designing for polymer AM and applicable design guidelines, and a chapter on designing for metal AM and its corresponding design guidelines. These chapters also address health and safety, certification and quality aspects. A dedicated chapter covers the multiple post-processing methods for AM, offering the reader practical guidance on how to get their parts from the AM machine into a shape that is ready to use. The book’s final chapter outlines future applications of AM. The main benefit of the book is its highly practical approach: it provides directly applicable, “hands-on” information and insights to help readers adopt AM in their industry

Introduction to Design Optimization Springer

In the present work we introduce a novel graded-material design for additive manufacturing based on phase-field and topology optimization. The main novelty of this work comes from the introduction of an additional phase-field variable in the classical single-material phase-field topology optimization algorithm. This new variable is used to grade the material properties in a continuous fashion. Two different numerical examples are discussed, in both of them we perform sensitivity studies to asses the effects of different model parameters onto the resulting structure. From the presented results we can observe that the proposed algorithm adds additional freedom in the design, exploiting the higher flexibility coming from additive manufacturing technology.

Developments of Topology Optimization

Methods for Additive Manufacturing Involving High-cycle Fatigue Springer Nature Topology optimization is a relatively new and rapidly expanding field of structural mechanics. It deals with some of the most difficult problems of mechanical sciences but it is also of considerable practical interest, because it can achieve much greater savings than mere cross-section or shape optimization.

Digitalization of design for support structures in laser powder bed fusion of metals Createspace Independent Publishing Platform Metal additive manufacturing (MAM) is an exciting emergent technology that offers the possibility of democratizing metal manufacturing worldwide. Many believe it has the ability to revolutionize product manufacturing on a global scale. MAM will require a considerable design shift for manufacturers and, hence, will disrupt conventional thinking and require adaptation. Visionaries in the mobility industry can see the transformative possibilities after materials considerations are addressed./ Materials Technology Gaps in Metal Additive Manufacturing introduces the reader to various opportunities and relationships in the study of material technologies involved in metal-based additive manufacturing of aerospace and automotive parts. Everything starts and ends with the material feedstock, and the intermediate processes that affect a particular metal. Each of the choices in the complex integrated MAM system impacts final-part properties. Edited by Dr. Cynthia K. Waters, from North Carolina A&T State University, Materials Technology Gaps in Metal Additive Manufacturing is a highly curated collection of 10 seminal SAE International papers. They discuss the various technologies involved in MAM, and draw attention to the materials needs in each of the situations addressed. The main topics included in Materials Technology Gaps in Metal Additive Manufacturing are: Process design and material modeling Metal powder selection and study Additive processing parameters' effect on materials properties As more interdependencies of material properties and possible manufacturing processes evolve (compatibility interdependence), questions if the specific manufacturing process is capable to create the required geometry will also arise. Materials Technology Gaps in Metal Additive Manufacturing brings innovative ways to address these and other challenges that are always present in the adoption of novel technologies.

Design for Additive Manufacturing Butterworth-Heinemann Additive manufacturing (AM) is a fast-growing sector with the ability to evoke a revolution in manufacturing due to its almost unlimited design freedom and its capability to produce personalised parts locally and with efficient material use. AM companies, however, still face technological challenges such as limited precision due to shrinkage, built-in stresses and limited process stability and robustness. Moreover, often post-processing is needed due to high roughness and remaining porosity. Qualified, trained personnel are also in short supply. In recent years, there have been dramatic improvements in

AM design methods, process control, post-processing, material properties and material range. However, if AM is going to gain a significant market share, it must be developed into a true precision manufacturing method. The production of precision parts relies on three principles: Production is robust (i.e. all sensitive parameters can be controlled). Production is predictable (for example, the shrinkage that occurs is acceptable because it can be predicted and compensated in the design). Parts are measurable (as without metrology, accuracy, repeatability and quality assurance cannot be known). AM of metals is inherently a high-energy process with many sensitive and inter-related process parameters, making it susceptible to thermal distortions, defects and process drift. The complete modelling of these processes is beyond current computational power, and novel methods are needed to practicably predict performance and inform design. In addition, metal AM produces highly textured surfaces and complex surface features that stretch the limits of contemporary metrology. With so many factors to consider, there is a significant shortage of background material on how to inject precision into AM processes. Shortage in such material is an important barrier for a wider uptake of advanced manufacturing technologies, and a comprehensive book is thus needed. This book aims to inform the reader how to improve the precision of metal AM processes by tackling the three principles of robustness, predictability and metrology, and by developing computer-aided engineering methods that empower rather than limit AM design. Richard Leach is a professor in metrology at the University of Nottingham and heads up the Manufacturing Metrology Team. Prior to this position, he was at the National Physical Laboratory from 1990 to 2014. His primary love is instrument building, from concept to final installation, and his current interests are the dimensional measurement of precision and additive manufactured structures. His research themes include the measurement of surface topography, the development of methods for measuring 3D structures, the development of methods for controlling large surfaces to high resolution in industrial applications and the traceability of X-ray computed tomography. He is a leader of several professional societies and a visiting professor at Loughborough University and the Harbin Institute of Technology. Simone Carmignato is a professor in manufacturing engineering at the University of Padua. His main research activities are in the areas of precision manufacturing, dimensional metrology and industrial computed tomography. He is the author of books and hundreds of scientific papers, and he is an active member of leading technical and scientific societies. He has been chairman, organiser and keynote speaker for several international conferences, and received national and international awards, including the Taylor Medal from CIRP, the International Academy for Production Engineering.

TOPOLOGY OPTIMIZATION ALGORITHMS FOR ADDITIVE MANUFACTURING.

Elsevier
This book addresses the emerging needs of the aerospace industry by discussing recent developments and future trends of aeronautic materials. It is aimed at advancing existing materials and fostering the ability to develop novel materials with less weight, increased mechanical properties, more functionality, diverse manufacturing methods, and recyclability. The development of novel materials and multifunctional materials has helped to increase efficiency and safety, reduce costs, and decrease the environmental foot print of the aeronautical industry. In this book, integral metallic structures designed by disruptive concepts, including topology optimization and additive manufacturing, are highlighted.

Additive Manufacturing Technologies From an Optimization Perspective Elsevier
Topology optimization is an exciting and powerful method for generating insightful, high-performance designs. The objectives of this text are to introduce the readers to topology optimization terminology, illustrate various sensitivity analysis techniques, and, most importantly, provide numerous examples and case-studies to illustrate the merits of topology optimization. The primary audience include senior undergraduate students, first year graduate students and practicing engineers. No prior background in topology optimization is assumed. However, a working knowledge of finite element analysis (FEA) is helpful. Pareto, a topology optimization software developed at the University of Wisconsin-Madison, is used throughout the text to illustrate the main concepts. However, the reader could potentially use other topology optimization software capable of handling the class of problems posed in this text.

Metamaterial Design and Additive Manufacturing Springer
This open access book gives both a theoretical and practical overview of several important aspects of additive manufacturing (AM). It is written in an educative style to enable the reader to understand and apply the material. It begins with an introduction to AM technologies and the general workflow, as well as an overview of the current standards within AM. In the following chapter, a more in-depth description is given of design optimization and simulation for AM in polymers and metals, including practical guidelines for topology optimization and the use of lattice structures. Special attention is also given to the economics of AM and when the technology offers a benefit compared to conventional manufacturing processes. This is followed by a chapter with practical insights into how AM materials and processing parameters are developed for both material extrusion and powder bed fusion. The final chapter describes functionally graded AM in various materials and technologies. Throughout the book, a large number of industrial applications are described to exemplify the benefits of AM.

Additive Manufacturing Graded-material Design Based on Phase-field and Topology Optimization Springer
The book covers additive manufacturing of

polymers, metals, ceramics and ceramic composites, fiber reinforced composites, energy harvesting materials, and biomaterials. Hybrid manufacturing is discussed. Topology optimization methodology is described and finite element software examples are provided. The book is ideal for graduate students and career starters in the industry.

Additive Manufacturing Technologies John Wiley & Sons

This Handbook is the ultimate definitive guide that covers key fundamentals and advanced applications for Additive Manufacturing. The Handbook has been structured into seven sections, comprising of a thorough Introduction to Additive Manufacturing; Design and Data; Processes; Materials; Post-processing, Testing and Inspection; Education and Training; and Applications and Case Study Examples. The general principles and functional relationships are described in each chapter and supplemented with industry use cases. The aim of this book is to help designers, engineers and manufacturers understand the state-of-the-art developments in the field of Additive Manufacturing. Although this book is primarily aimed at students and educators, it will appeal to researchers and industrial professionals working with technology users, machine or component manufacturers to help them make better decisions in the implementation of Additive Manufacturing and its applications.

Additive Manufacturing of Metals: The Technology, Materials, Design and Production Springer

This textbook covers in detail digitally-driven methods for adding materials together to form parts. A conceptual overview of additive manufacturing is given, beginning with the fundamentals so that readers can get up to speed quickly. Well-established and emerging applications such as rapid prototyping, micro-scale manufacturing, medical applications, aerospace manufacturing, rapid tooling and direct digital manufacturing are also discussed. This book provides a comprehensive overview of additive manufacturing technologies as well as relevant supporting technologies such as software systems, vacuum casting, investment casting, plating, infiltration and other systems. Reflects recent developments and trends and adheres to the ASTM, SI and other standards; Includes chapters on topics that span the entire AM value chain, including process selection, software, post-processing, industrial drivers for AM, and more; Provides a broad range of technical questions to ensure comprehensive understanding of the concepts covered.

Materials Technology Gaps in Metal Additive Manufacturing Springer

This book is a comprehensive guide to Additive Manufacturing (AM) product development. It offers a practical, reader-friendly approach to integrating the stages of product development. It covers current design and manufacturing strategies with a step-by-step approach, divided into three pillars: design, processes, and applications. The book addresses the challenges hindering the industrial application of AM and provides a roadmap for its successful implementation. It

discusses specific AM case studies and hybrid AM cell and production line setups, with the goal of achieving high-quality, low-cost products that are both flexible and productive. The book concludes with an examination of Industry 4.0 capabilities in decentralized manufacturing. It is aimed to be read by researchers and professionals in industry who are interested in the development and potential of additive manufacturing, and will help to lead to wider adoption of AM.

Topology Optimization for Additive Manufacturing Involving High-Cycle Fatigue Walter de Gruyter GmbH & Co KG

This book offers a unique guide to the three-dimensional (3D) printing of metals. It covers various aspects of additive, subtractive, and joining processes used to form three-dimensional parts with applications ranging from prototyping to production. Examining a variety of manufacturing technologies and their ability to produce both prototypes and functional production-quality parts, the individual chapters address metal components and discuss some of the important research challenges associated with the use of these technologies. As well as exploring the latest technologies currently under development, the book features unique sections on electron beam melting technology, material lifting, and the importance this science has in the engineering context. Presenting unique real-life case studies from industry, this book is also the first to offer the perspective of engineers who work in the field of aerospace and transportation systems, and who design components and manufacturing networks. Written by the leading experts in this field at universities and in industry, it provides a comprehensive textbook for students and an invaluable guide for practitioners

Additive Manufacturing – Developments in Training and Education CRC Press

METAL ADDITIVE MANUFACTURING A comprehensive review of additive manufacturing processes for metallic structures Additive Manufacturing (AM)—also commonly referred to as 3D printing—builds three-dimensional objects by adding materials layer by layer. Recent years have seen unprecedented investment in additive manufacturing research and development by governments and corporations worldwide. This technology has the potential to replace many conventional manufacturing processes, enable the development of new industry practices, and transform the entire manufacturing enterprise. Metal Additive Manufacturing provides an up-to-date review of all essential physics of metal additive manufacturing techniques with emphasis on both laser-based and non-laser-based additive manufacturing processes. This comprehensive volume covers fundamental processes and equipment, governing physics and modelling, design and topology optimization, and more. The text adresses introductory, intermediate, and advanced topics ranging from basic additive manufacturing process classification to practical and material design aspects of additive manufacturability. Written by a panel of expert authors in the field, this

authoritative resource: Provides a thorough analysis of AM processes and their theoretical foundations Explains the classification, advantages, and applications of AM processes Describes the equipment required for different AM processes for metallic structures, including laser technologies, positioning devices, feeder and spreader mechanisms, and CAD software Discusses the opportunities, challenges, and current and emerging trends within the field Covers practical considerations, including design for AM, safety, quality assurance, automation, and real-time control of AM processes Includes illustrative cases studies and numerous figures and tables Featuring material drawn from the lead author's research and professional experience on laser additive manufacturing, Metal Additive Manufacturing is an important source for manufacturing professionals, research and development engineers in the additive industry, and students and researchers involved in mechanical, mechatronics, automatic control, and materials engineering and science.

Optimization and Uncertainty Quantification for Geometric Structures Springer Nature

This book presents the latest advances in computational and parametric design engineering, as well as digital tools related to manufacturing. It covers design and manufacturing process such as CAD-based design/manufacturing, parametric design, algorithmic design and process automation, and several digital tools and applications.

Additive Manufacturing: Design, Processes and Applications Topology Optimization for Additive Manufacturing Involving High-Cycle Fatigue Theoretical and practical interests in additive manufacturing (3D printing) are growing rapidly. Engineers and engineering companies now use 3D printing to make prototypes of products before going for full production. In an educational setting faculty, researchers, and students leverage 3D printing to enhance project-related products. Additive Manufacturing Handbook focuses on product design for the defense industry, which affects virtually every other industry. Thus, the handbook provides a wide range of benefits to all segments of business, industry, and government. Manufacturing has undergone a major advancement and technology shift in recent years.

Topology Optimization of Compliant Mechanisms Springer

Additive manufacturing is considered a key technology for digital production. However, several barriers towards the broad industrial application exist, e.g. the associated cost and the required experience regarding the manufacturing process. To eradicate these barriers, the complete digitalization of the value creation process is needed. In this thesis, a digital, automated support structuredesign procedure is developed. Topology optimization is used for design rule determination, and the space colonization algorithm is adapted for the automated design. The validity of the procedure is proven experimentally, revealing sufficient mechanical performance alongside cost reduction at medium to large production scales.

Additive Manufacturing Springer Nature Topology Optimization in Engineering Structure Design explores the recent advances and applications of topology optimization in engineering structures design, with a particular focus on aircraft and aerospace structural systems. To meet the increasingly complex engineering challenges provided by rapid developments in these industries, structural optimization techniques have developed in conjunction with them over the past two decades. The latest methods and theories to improve mechanical performances and save structural weight under static, dynamic and thermal loads are summarized and explained in detail here, in addition to potential applications of topology optimization techniques such as shape preserving design, smart structure design and additive manufacturing. These new design strategies are illustrated by a host of worked examples, which are inspired by real engineering situations, some of which have been applied to practical structure design with significant effects. Written from a forward-looking applied engineering perspective, the authors not only summarize the latest developments in this field of structure design but also provide both theoretical knowledge and a practical guideline. This book should appeal to graduate students, researchers and engineers, in detailing how to use topology optimization methods to improve product design. Combines practical applications and topology optimization methodologies Provides problems inspired by real engineering difficulties Designed to help researchers in universities acquire more engineering requirements