



Strategic materials selection in the automobile body: Economic opportunities for polymer composite design

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Abstract

Previous studies on materials choice in automotive bodies have looked at both composite and aluminum alternatives, but have always found steel to be the most cost-effective option at the production volumes found in the overwhelming majority of vehicle models. This study finds composites to have significant economic potential when considering emerging advances in the polymer composite body-in-white design against the mild-grade steel body currently on the road. With the significant implications of a polymer composite body for vehicle light-weighting and thereby improved fuel efficiency, these results come at a time when they are particularly pertinent.

The results presented in this paper are based on a consortium-developed, 25-part unibody design not available to previous studies. Also presented for the first time are data on competing alternatives in fiber composite component assembly and implications of platform sharing across vehicle models. Finally, developments in process-based cost modeling capabilities are presented for (a) fiber-reinforced composite component production, (b) component assembly, and (c) design implications of glass versus carbon reinforcement.

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Keywords: A. Carbon fiber; A. Glass fiber; A. Structural composites; C. Modelling; E. Injection molding; Automobiles

1. Materials selection in automotive body-in-whites: technologies and demands

Regulatory constraints on energy consumption have influenced vehicle development for over three decades. With recent rises in oil prices due to increasing demand and unrest in the Middle East, and the increased prominence of global warming and other environmental concerns in the popular press, technological advances to improve vehicle efficiency are becoming increasingly important to competitiveness in the global automobile market [1–5].

One key technical design strategy for improving vehicle efficiency is the reduction of vehicle mass, or light-weighting. Vehicle light-weighting not only enhances fuel efficiency, but also lowers vehicle emissions and improves

driving performance.¹ Light-weight subsystems such as hoods and decklids are already employed throughout the industry to achieve small weight savings. However, significant improvements in vehicle efficiency will require larger changes in mass. A primary target for this mass reduction is the body-in-white, whose standard steel version comprises 20–25% of total vehicle curb weight.

The two main strategic approaches for reducing weight in the body-in-white are architectural changes and material substitution. Among architecture alternatives, the unibody is most mass efficient and is already ubiquitous [6]. Consequently, the primary mechanisms available for further reducing the weight of the body-in-white is the use of alternative materials. This study examines the potential cost-competi-

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¹ Alternatively, lighter structures can allow for additional weight in the form of electrical conveniences such as DVD players, navigation systems, and additional motorized options.

Strategic Materials Selection In The Automobile Body

**Yusuke Kishita,Mitsutaka
Matsumoto,Masato Inoue,Shinichi
Fukushige**



Strategic Materials Selection In The Automobile Body:

Proceedings of the European Automotive Congress EAEC-ESFA 2015 Cristian Andreescu, Adrian Clenci, 2015-11-25 The volume includes selected and reviewed papers from the European Automotive Congress held in Bucharest Romania in November 2015 Authors are experts from research industry and universities coming from 14 countries worldwide The papers are covering the latest developments in fuel economy and environment automotive safety and comfort automotive reliability and maintenance new materials and technologies traffic and road transport systems advanced engineering methods and tools as well as advanced powertrains and hybrid and electric drives

TMS 2022 151st Annual Meeting & Exhibition

Supplemental Proceedings The Minerals, Metals & Materials Society, 2022-02-07 This collection presents papers from the 151st Annual Meeting Exhibition of The Minerals Metals Materials Society

Energy Efficiency and Sustainable Lighting Manuel J. Hermoso-Orzáez, Alfonso Gago-Calderón, 2020-03-25 The lighting of both exteriors and interiors is a field within electrical and lighting engineering where important technological changes have been taking place oriented towards environmental sustainability and energy efficiency LED technology has been gradually gaining ground in the world of lighting over other technologies due to its high lighting and energy efficiency and savings However some problems related to overheating or associated regulation are emerging This has prompted the search for new more efficient and sustainable forms of lighting This book presents successful cases related to energy efficiency and lighting that may be of great interest to those trying to enter the world of scientific research

Structural Materials and Processes in Transportation

Dirk Lehmhus, Matthias Busse, Axel Herrmann, Kambiz Kayvantash, 2013-08-07 Lightness efficiency durability and economic as well as ecological viability are key attributes required from materials today In the transport industry the performance needs are felt exceptionally strongly This handbook and ready reference covers the use of structural materials throughout this industry particularly for the road air and rail sectors A strong focus is placed on the latest developments in materials engineering The authors present new insights and trends providing firsthand information from the perspective of universities Fraunhofer and independent research institutes aerospace and automotive companies and suppliers Arranged into parts to aid the readers in finding the information relevant to their needs Metals Polymers Composites Cellular Materials Modeling and Simulation Higher Level Trends

EcoDesign and Sustainability I

Yusuke Kishita, Mitsutaka Matsumoto, Masato Inoue, Shinichi Fukushima, 2020-11-02 This book highlights cutting edge ecodesign research covering product and service design smart manufacturing and social perspectives in ecodesign Featuring selected papers presented at EcoDesign 2019 11th International Symposium on Environmentally Conscious Design and Inverse Manufacturing it also includes diverse interdisciplinary approaches to foster ecodesign research and activities In the context of Sustainable Development Goals SDGs it addresses the need for the manufacturing industry to design innovations for sustainable value creation taking into account technological developments legislation and consumer lifestyles Further the book discusses the concept of circular

economy which originated in Europe and aims to increase resource efficiency by shifting away from the linear economy Focusing on product life cycle design and management smart manufacturing circular economy and business strategies and providing useful approaches and solutions to these emerging concepts this book is intended for both researchers and practitioners working in the broad field of ecodesign and sustainability Composite Materials in Design Processes Giangiacomo Minak,2021-09-02 The use of composite materials in the design process allows one to tailor a component's mechanical properties thus reducing its overall weight On the one hand the possible combinations of matrices reinforcements and technologies provides more options to the designer On the other hand it increases the fields that need to be investigated in order to obtain all the information requested for a safe design This Applied Sciences Special Issue Composite Materials in Design Processes collects recent advances in the design methods for components made of composites and composite material properties at a laminate level or using a multi scale approach Automotive Manufacturing Processes G.K. Awari,V.S. Kumbhar,R.B. Tirpude,S.W. Rajurkar,2023-07-14 Automotive Manufacturing Processes discusses basic principles and operational procedures of automotive manufacturing processes issues in the automotive industry like material selection and troubleshooting Every chapter includes specific learning objectives multiple choice questions to test conceptual understanding of the subject and put theory into practice review questions solved problems and unsolved exercises It covers important topics including material decision making processes surface hardening processes heat treatment processes effects of friction and velocity distribution the metallurgical spectrum of forging and surface finishing processes Features Discusses automotive manufacturing processes in a comprehensive manner with the help of applications Provides case studies addressing issues in the automotive industry and manufacturing operations in the production of vehicles Discussion on material properties while laying emphasis on the materials and processing parameters Covers applications and case studies of the automotive industry The text will be useful for senior undergraduates graduate students and academic researchers in areas including automobile engineering industrial and manufacturing engineering and mechanical engineering

Experimental Characterization, Predictive Mechanical and Thermal Modeling of Nanostructures and Their Polymer Composites Francesco Marotti De Sciarra,Pietro Russo,2018-03-23 Experimental Characterization Predictive Mechanical and Thermal Modeling of Nanostructures and Their Polymer Composite focuses on the recent observations and predictions regarding the size dependent mechanical properties material properties and processing issues of carbon nanotubes CNTs and other nanostructured materials The book takes various approaches including dedicated characterization methods theoretical approaches and computer simulations providing a detailed examination of the fundamental mechanisms governing the deviations of the properties of CNTs and other nanostructured materials The book explores their applications in materials science mechanics engineering chemistry and physics due to their unique and appealing properties The use of such materials is however still largely limited due to the difficulty in tuning their properties and morphological and structural

features Presents a thorough discussion on how to effectively model the properties of carbon nanotubes and their polymer nanocomposites Includes a size dependent analysis of properties and multiscale modeling Outlines the fundamentals and procedures of computational modeling as it is applied to carbon nanotubes and other nanomaterials **Lightweight**

Composite Structures in Transport James Njuguna,2016-01-22 Lightweight Composite Structures in Transport Design Manufacturing Analysis and Performance provides a detailed review of lightweight composite materials and structures and discusses their use in the transport industry specifically surface and air transport The book covers materials selection the properties and performance of materials and structures design solutions and manufacturing techniques A broad range of different material classes is reviewed with emphasis on advanced materials Chapters in the first two parts of the book consider the lightweight philosophy and current developments in manufacturing techniques for lightweight composite structures in the transport industry with subsequent chapters in parts three to five discussing structural optimization and analysis properties and performance of lightweight composite structures durability damage tolerance and structural integrity Final chapters present case studies on lightweight composite design for transport structures Comprehensively covers materials selection design solutions manufacturing techniques structural analysis and performance of lightweight composite structures in the transport industry Includes commentary from leading industrial and academic experts in the field who present cutting edge research on advanced lightweight materials for the transport industry Includes case studies on lightweight composite design for transport structures **Non-Conventional Machining in Modern Manufacturing**

Systems Kumar, Kaushik,Kumari, Nisha,Davim, J. Paulo,2018-09-21 Continuous improvements in machining practices have created opportunities for businesses to develop more streamlined processes This not only leads to higher success in day to day production but also increases the overall success of businesses Non Conventional Machining in Modern Manufacturing Systems provides emerging research exploring the theoretical and practical aspects of technological advancements in industrial environments and applications in manufacturing Featuring coverage on a broad range of topics such as optimization techniques electrical discharge machining and hot machining this book is ideally designed for business managers engineers business professionals researchers and academicians seeking current research on non conventional and technologically advanced machining processes **Simulation of the thermoforming process of UD fiber-reinforced**

thermoplastic tape laminates Dörr, Dominik,2021-10-29 In this work initially the requirements on a simulation model of the non isothermal stamp forming process of unidirectional fiber reinforced and thermoplastic tape laminates are investigated experimentally On this basis different isothermal as well as a fully coupled thermomechanical simulation model under consideration of the crystallization kinetics are developed For validation a complex shaped geometry is simulated and compared to experimental forming results Industrial Applications of Polymer Composites Subhendu Bhandari,Prashant

Gupta,Ayan Dey,2023-08-22 This volume is a comprehensive guide to the industrial use of polymer composites Edited

contributions demonstrate the application of these materials for different industrial sectors. The book covers the benefits, future potential and manufacturing techniques of different types of polymers. Contributors also address challenges in using nanopolymers in these industries. Readers will find valuable insights into the current demand and supply of polymer composites and future scope for research and development in this field of polymer science. The volume presents seven chapters each exploring a different application of polymer composites. Chapter 1 discusses the use of polymer additives for improving classical concrete and the workability and durability of polymer composite concrete. Chapter 2 explores the use of polymer nanocomposites in packaging including smart intelligent packaging, modified atmosphere packaging and vacuum packaging. Chapter 3 delves into the use of polymer composites in tissue engineering including manufacturing techniques and various applications. Chapter 4 explores energy storage applications for polymer composites while Chapter 5 discusses their use in microbial fuel cells. Chapter 6 explores the use of carbon nanotubes in polymer composite gas sensors. Finally, Chapter 7 discusses the use of polymer composites in automotive applications. This is an ideal reference for researchers, scientists, engineers and professionals in the fields of materials science, polymer science, engineering and nanotechnology. The content is also suitable for graduate and postgraduate students studying industrial manufacturing. **International**

Encyclopedia of Transportation, 2021-05-13 In an increasingly globalised world, despite reductions in costs and time, transportation has become even more important as a facilitator of economic and human interaction. This is reflected in technical advances in transportation systems, increasing interest in how transportation interacts with society and the need to provide novel approaches to understanding its impacts. This has become particularly acute with the impact that Covid 19 has had on transportation across the world at local, national and international levels. Encyclopedia of Transportation, Seven Volume Set, containing almost 600 articles, brings a cross-cutting and integrated approach to all aspects of transportation from a variety of interdisciplinary fields including engineering, operations, research, economics, geography and sociology in order to understand the changes taking place. Emphasising the interaction between these different aspects of research, it offers new solutions to modern-day problems related to transportation. Each of its nine sections is based around familiar themes but brings together the views of experts from different disciplinary perspectives. Each section is edited by a subject expert who has commissioned articles from a range of authors representing different disciplines, different parts of the world and different social perspectives. The nine sections are structured around the following themes: Transport Modes, Freight Transport and Logistics, Transport Safety and Security, Transport Economics, Traffic Management, Transport Modelling and Data Management, Transport Policy and Planning, Transport Psychology, Sustainability and Health Issues in Transportation. Some articles provide a technical introduction to a topic whilst others provide a bridge between topics or a more future-oriented view of new research areas or challenges. The end result is a reference work that offers researchers and practitioners new approaches, new ways of thinking and novel solutions to problems. All encompassing and expertly authored.

this outstanding reference work will be essential reading for all students and researchers interested in transportation and its global impact in what is a very uncertain world Provides a forward looking and integrated approach to transportation Updated with future technological impacts such as self driving vehicles cyber physical systems and big data analytics Includes comprehensive coverage Presents a worldwide approach including sets of comparative studies and applications

Mesoscale simulation of the mold filling process of Sheet Molding Compound Meyer, Nils, 2022-07-12 Sheet Molding Compounds SMC are discontinuous fiber reinforced composites that are widely applied due to their ability to realize composite parts with long fibers at low cost A novel Direct Bundle Simulation DBS method is proposed in this work to enable a direct simulation at component scale utilizing the observation that fiber bundles often remain in a bundled configuration during SMC compression molding

The Structural Integrity of Carbon Fiber Composites Peter W. R Beaumont, Constantinos Soutis, Alma Hodzic, 2016-11-26 This book brings together a diverse compilation of inter disciplinary chapters on fundamental aspects of carbon fiber composite materials and multi functional composite structures including synthesis characterization and evaluation from the nano structure to structure meters in length The content and focus of contributions under the umbrella of structural integrity of composite materials embraces topics at the forefront of composite materials science and technology the disciplines of mechanics and development of a new predictive design methodology of the safe operation of engineering structures from cradle to grave Multi authored papers on multi scale modelling of problems in material design and predicting the safe performance of engineering structure illustrate the inter disciplinary nature of the subject The book examines topics such as Stochastic micro mechanics theory and application for advanced composite systems Construction of the evaluation process for structural integrity of material and structure Nano and meso mechanics modelling of structure evolution during the accumulation of damage Statistical meso mechanics of composite materials Hierarchical analysis including age aware high fidelity simulation and virtual mechanical testing of composite structures right up to the point of failure The volume is ideal for scientists engineers and students interested in carbon fiber composite materials and other composite material systems

Metal Matrix Composites Suneev Anil Bansal, Virat Khanna, Pallav Gupta, 2022-08-23 This book gives in depth coverage of Metal Matrix Composites MMCs focusing on micro and nano reinforcements including hybrid structures and applications like tribological and corrosion behavior heat exchanger and so forth Each chapter covers different perspectives of micro nano reinforcement and related applications Major topics covers include new age reinforcement fracture and corrosion behavior tribological elastic elastoplastic and thermal behavior of MMCs Features Presents detailed analysis on new age reinforcements in Metal Matrix Composites MMCs Discusses application based analysis of MMCs Covers details about convergence of hybrid composite from conventional alloys Includes mechanisms and effects of various reinforcement on pertinent properties Reviews properties and applications of various MMCs This book aims at graduate students researchers and professionals in micro nano science technology mechanical

engineering industrial engineering metallurgy and composites **Numerical prediction of curing and process-induced distortion of composite structures** Bernath, Alexander, 2021-10-29 Fiber reinforced materials offer a huge potential for lightweight design of load bearing structures However high volume production of such parts is still a challenge in terms of cost efficiency and competitiveness Numerical process simulation can be used to analyze underlying mechanisms and to find a suitable process design In this study the curing process of the resin is investigated with regard to its influence on RTM mold filling and process induced distortion **Leveraging Technology for a Sustainable World** David A. Dornfeld, Barbara S. Linke, 2012-04-23 The 19th CIRP Conference on Life Cycle Engineering continues a strong tradition of scientific meetings in the areas of sustainability and engineering within the community of the International Academy for Production Engineering CIRP The focus of the conference is to review and discuss the current developments technology improvements and future research directions that will allow engineers to help create green businesses and industries that are both socially responsible and economically successful The symposium covers a variety of relevant topics within life cycle engineering including Businesses and Organizations Case Studies End of Life Management Life Cycle Design Machine Tool Technologies for Sustainability Manufacturing Processes Manufacturing Systems Methods and Tools for Sustainability Social Sustainability and Supply Chain Management The Multi Material Lightweight Vehicle (MMLV) Project David Wagner, Jeff L Conklin, Matthew Zaluzec, Timothy W Skszek, 2015-06-05 The desire for greater fuel efficiency and reduced emissions have accelerated a shift from traditional materials to design solutions that more closely match materials and their properties with key applications The Multi Material Lightweight Vehicle MMLV Project presents cutting edge engineering that meets future challenges in a concept vehicle with weight and life cycle assessment savings These results significantly contribute to achieving fuel reduction and to meeting future Corporate Average Fuel Economy CAF regulations without compromising vehicle performance or occupant safety The MMLV Project presents Lightweight materials applications Body in white design and computer aided engineering Engine and transmission design and lightweighting Full vehicle test results that are specific to the MMLV subsystems including crash corrosion durability and Noise Vibration and Harshness NVH The Life Cycle Analysis LCA for the MMLV The aluminum intensive structure combined with carbon fiber magnesium and titanium results in full vehicle mass reduction of a C D class family sedan to that of a subcompact B car two vehicle segments lighter The MMLV Project presents engineering solutions that frame materials selection and applications for the future *Sustainable Composites for Aerospace Applications* Mohammad Jawaid, Mohamed Thariq Hameed Sultan, 2018-04-27 Sustainable Composites for Aerospace Applications presents innovative advances in the fabrication characterization and applications of LDH polymer nanocomposites It covers fundamental structural and chemical knowledge and explores various properties and characterization techniques including microscopic spectroscopic and mechanical behaviors Users will find a strong focus on the potential applications of LDH polymer nanocomposites such as in energy electronics electromagnetic shielding

biomedical agricultural food packaging and water purification functions This book provides comprehensive coverage of cutting edge research in the field of LDH polymer nanocomposites and future applications and is an essential read for all academics researchers engineers and students working in this area Presents fundamental knowledge of LDH polymer nanocomposites including chemical composition structural features and fabrication techniques Provides an analytical overview of the different types of characterization techniques and technologies Contains extensive reviews on cutting edge research for future applications in a variety of industries

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