



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

**Manuel J. Hermoso-Orzáez, Alfonso
Gago-Calderón**



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 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

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 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

Materials for Automobile Bodies Geoffrey Davies, 2012-03-30 1 Introduction 2 Design and material utilization 3 Materials for consideration and use in automotive body structures 4 The role of demonstration concept and competition cars 5 Component manufacture 6 Component assembly materials joining technology 7 Corrosion and protection of the automotive structure 8 Environmental considerations 9 Future trends in automotive body materials

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

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

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 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 Woven Composites M H Ferri Aliabadi, 2015-02-09 This unique volume presents the latest developments in the field of advanced woven and braided textile composites with particular emphasis on computational approaches finite elements meshfree Advanced textile composites such as woven braided knitted and stitched fabrics are increasingly being used as structural materials in industrial applications due to their efficiency at reinforcing more directions within a single layer and their ability to conform to surfaces with complex curvatures Furthermore textile composites provide improved impact resistance exceptional thermal fatigue and corrosion resistance as well as being easier and cheaper to handle and fabricate compared to UD composites Topics covered in this book include 2D and 3D plain twill satin woven and braided composites micro level and macro level modelling failure mechanisms theoretical studies on cryogenic crack behaviour and the specific deformation modes of textile reinforcements which include the kinematic and hypoelastic models This book will be particularly relevant to professional engineers graduate students and researchers interested in composite

materials **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 Carbon Fibre from Lignin Pratima Bajpai, 2017-03-20 This book presents detailed information on the production and properties of carbon fibers derived from lignin precursors Focusing on future directions in the carbon fiber industry it also introduces a novel process for obtaining high purity lignin a key aspect in the manufacture of high quality carbon fiber Carbon fiber is currently the most preferred lightweight manufacturing material and is rapidly becoming the material of choice for manufacturers around the world Although more than 80% of commercial carbon fiber is estimated to use PAN polyacrylonitrile as a precursor carbon fiber manufactured from PAN is expensive and therefore its application is limited to high performance structural materials Lignin is the second most abundant biopolymer in nature after cellulose and offers a carbon rich renewable resource As a byproduct of the pulp and paper industry and the production of cellulosic ethanol lignin is also available at low cost making it an economically attractive alternative to PAN for the production of carbon fibers as highlighted in this book The information presented will be of interest to all those involved in the investigation of carbon fiber materials carbon fiber manufacturers and carbon fiber users **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 *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

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

Materials Selection for Design and Manufacturing Joseph Datsko,2020-09-10 Providing an analytical approach to selecting the best metal and obtaining optimal properties for and in a fabricated part this text correlates weldability formability and machinability with a metal s chemical composition through microstructures It begins with a review of the principles of materials science and offers useful features such as end of chapter problems and a solutions manual

Reinventing Fire Amory Lovins,2011-10-15 Oil and coal have built our civilization created our wealth and enriched the lives of billions Yet their rising costs to our security economy health and environment now outweigh their benefits Moreover that long awaited energy tipping point where alternatives work better than oil and coal and compete purely on cost is no longer decades in the future It is here and now And it is the fulcrum of economic transformation A global clean energy race has emerged with astounding speed The ability to operate without fossil fuels will define winners and losers in business and among nations In Reinventing Fire Amory Lovins and Rocky Mountain Institute offer a new vision to revitalize business models end run Washington gridlock and win the clean energy race not forced by public policy but led by business for enduring profit This groundbreaking roadmap reveals market based solutions across the transportation building industry and electricity sectors It highlights pathways and competitive strategies for a 158% bigger 2050 U S economy that needs no oil no coal no nuclear energy one third less natural gas and no new inventions This transition would cost 5 trillion less than business as usual without counting fossil fuels huge hidden costs It requires no new federal taxes subsidies mandates or laws The policy innovations needed to unlock and speed it need no Act of Congress Whether you care most about profits and jobs national security health or environmental stewardship Reinventing Fire charts a pragmatic course that makes sense and makes money With clarity and mastery Lovins and RMI point out the astounding opportunities for enterprises to create the new energy era Drawing praise from President Bill Clinton former National Security Advisor Robert McFarlane and a host of others Reinventing Fire has piqued the interest of world leaders business leaders and political strategists

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

Advanced Composite Materials for Automotive Applications Ahmed Elmarakbi,2013-10-09 The automotive industry faces

many challenges including increased global competition the need for higher performance vehicles a reduction in costs and tighter environmental and safety requirements The materials used in automotive engineering play key roles in overcoming these issues ultimately lighter materials mean lighter vehicles and lower emissions Composites are being used increasingly in the automotive industry due to their strength quality and light weight Advanced Composite Materials for Automotive Applications Structural Integrity and Crashworthiness provides a comprehensive explanation of how advanced composite materials including FRPs reinforced thermoplastics carbon based composites and many others are designed processed and utilized in vehicles It includes technical explanations of composite materials in vehicle design and analysis and covers all phases of composite design modelling testing and failure analysis It also sheds light on the performance of existing materials including carbon composites and future developments in automotive material technology which work towards reducing the weight of the vehicle structure Key features Chapters written by world renowned authors and experts in their own fields Includes detailed case studies and examples covering all aspects of composite materials and their application in the automotive industries Unique topic integration between the impact crash failure damage analysis and modelling of composites Presents the state of the art in composite materials and their application in the automotive industry Integrates theory and practice in the fields of composite materials and automotive engineering Considers energy efficiency and environmental implications Advanced Composite Materials for Automotive Applications Structural Integrity and Crashworthiness is a comprehensive reference for those working with composite materials in both academia and industry and is also a useful source of information for those considering using composites in automotive applications in the future

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