

Review

# An Overview of the Recent Advances in Composite Materials and Artificial Intelligence for Hydrogen Storage Vessels Design

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**Abstract:** The environmental impact of CO<sub>2</sub> emissions is widely acknowledged, making the development of alternative propulsion systems a priority. Hydrogen is a potential candidate to replace fossil fuels for transport applications, with three technologies considered for the onboard storage of hydrogen: storage in the form of a compressed gas, storage as a cryogenic liquid, and storage as a solid. These technologies are now competing to meet the requirements of vehicle manufacturers; each has its own unique challenges that must be understood to direct future research and development efforts. This paper reviews technological developments for Hydrogen Storage Vessel (HSV) designs, including their technical performance, manufacturing costs, safety, and environmental impact. More specifically, an up-to-date review of fiber-reinforced polymer composite HSVs was explored, including the end-of-life recycling options. A review of current numerical models for HSVs was conducted, including the use of artificial intelligence techniques to assess the performance of composite HSVs, leading to more sophisticated designs for achieving a more sustainable future.

**Keywords:** hydrogen storage; composite materials; transport applications; circular economy; recycling; artificial intelligence; sustainable development



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## 1. Introduction

Fossil fuels threaten the environment because they use natural resources, make greenhouse gases worse, and pollute the air. Cleaner energy is required [1–4], and hydrogen is a possible solution for transport applications. In addition to enabling the decarbonization of road transportation, hydrogen energy can also significantly reduce local air pollution [5]. Hydrogen is a non-toxic, colorless, and odorless gas with the highest energy density per mass compared to standard fuels, and more crucially, its fuel infrastructure is on par with traditional road fuels [6].

In the past few years, there has been a rise in the number of programs to make hydrogen meet energy and climate goals. Since 2000 [7], 230 projects have been launched worldwide to convert electrical energy to hydrogen (Figure 1). The capital costs of water electrolyzers installed in 2017 and 2018 are about USD 20–30 million annually. Additional investments in storage tanks, refueling infrastructure, pipes, and other equipment will make the total cost of a project even higher. Both alkaline and proton exchange membrane

# Recent Advances In Composite Materials

**Erian A. Armanios**



## **Recent Advances In Composite Materials:**

**Recent Advances in Composite Materials** E.E. Gdoutos, Zaira Marioli-Riga, 2013-04-17 This book contains 31 papers presented at the symposium on Recent Advances in Composite Materials which was organized in honor of Professor Stephanos A Paipetis The symposium took place at Democritus University of Thrace in Xanthi Greece on June 12 14 2003 The book is a tribute to Stephanos A Paipetis a pioneer of composite materials in recognition of his continuous original diversified and outstanding contributions for half a century The book consists of invited papers written by leading experts in the field It contains original contributions concerning the latest developments in composite materials It covers a wide range of subjects including experimental characterization analytical modeling and applications of composite materials The papers are arranged in the following six sections General concepts stress and failure analysis mechanical properties metal matrix composites structural analysis and applications of composite materials The first section on general concepts contains seven papers dealing with composites through the pursuit of the consilience among them computation and mechatronic automation of multiphysics research a theory of anisotropic scattering wave propagation multi material composite wedges a three dimensional finite element analysis around broken fibers and an in situ assessment of the micromechanics of large scale bridging in ceramic composites

**Recent Advances in Composites in the United States and Japan** Jack R. Vinson, 1985

**Recent Advances in Composite Materials** Scott R. White, H. Thomas Hahn, W. F. Jones, 1995

**Recent Advances in Composites Engineering and Research** Mulakaluri Rama Manohara Babu, Manoj Kumar Buragohain, Srinivas Kuchipudi, 2024-06-01 This volume presents select proceedings of ISAMPE National Conference on Composites INCCOM 17 The volume focuses on recent developments in the composite industry for manufacturing including aerospace defense civilian and automobile industries The content include chapters on research topics such as design analysis and simulation processing and composite tooling high temperature composites carbon carbon composites ultra high temperature composites nano and smart composites structural health monitoring material characterization non destructive evaluation of composite structures damage tolerance in composites composite process modelling and simulation composite repair technology AI in composites additive manufacturing of composites start up ideas in composite technology and applications of composites This volume will be of interest to researchers and professionals in the fields of materials and mechanical engineering

*Recent Advances in Composite Materials* E.E. Gdoutos, Zaira Marioli-Riga, 2003-05-31 This book contains 31 papers presented at the symposium on Recent Advances in Composite Materials which was organized in honor of Professor Stephanos A Paipetis The symposium took place at Democritus University of Thrace in Xanthi Greece on June 12 14 2003 The book is a tribute to Stephanos A Paipetis a pioneer of composite materials in recognition of his continuous original diversified and outstanding contributions for half a century The book consists of invited papers written by leading experts in the field It contains original contributions concerning the latest developments in composite materials It covers a wide range of subjects including experimental

characterization analytical modeling and applications of composite materials The papers are arranged in the following six sections General concepts stress and failure analysis mechanical properties metal matrix composites structural analysis and applications of composite materials The first section on general concepts contains seven papers dealing with composites through the pursuit of the consilience among them computation and mechatronic automation of multiphysics research a theory of anisotropic scattering wave propagation multi material composite wedges a three dimensional finite element analysis around broken fibers and an in situ assessment of the micromechanics of large scale bridging in ceramic composites

*Recent Advances in Structural Joints and Repairs for Composite Materials* Liyong Tong,C. Soutis,2013-03-09 Joints in components or structures incur a weight penalty are a source of failure cause manufacturing problems and are unfortunately unavoidable in most structures ranging from aircraft and spacecraft to ships and offshore platforms to automobiles bridges and buildings An important requirement for the complete design of practical structures is the development of attachment methods and joint designs *Recent Advances in Structural Joints and Repairs for Composite Materials* provides an up to date account of adhesively bonded and mechanically fastened joints and repairs Audience This book will prove to be an informative resource for all engineers and researchers involved with joining and repair of composite structures **Recent**

**Advances in Experimental Mechanics** E.E. Gdoutos,2007-05-08 This book contains 71 papers presented at the symposium on *Recent Advances in Experimental Mechanics* which was organized in honor of Professor Isaac M Daniel The symposium took place at Virginia Polytechnic Institute and State University on th June 23 28 2002 in conjunction with the 14 US National Congress of Applied Mechanics The book is a tribute to Isaac Daniel a pioneer of experimental mechanics and composite materials in recognition of his continuous original diversified and outstanding contributions for half a century The book consists of invited papers written by leading experts in the field It contains original contributions concerning the latest developments in experimental mechanics It covers a wide range of subjects including optical methods of stress analysis photoelasticity moir etc composite materials sandwich construction fracture mechanics fatigue and damage nondestructive evaluation dynamic problems fiber optic sensors speckle metrology digital image processing nanotechnology neutron diffraction and synchrotron radiation methods The papers are arranged in the following nine sections Mechanical characterization of material behavior composite materials fracture and fatigue optical methods n destructive evaluation neutron diffraction and synchrotron radiation methods hybrid methods composite structures and structural testing and analysis **Recent Advances in Composite Materials** V. K. Srivastava,Mrityunjay Singh,2004 **Recent Advances in**

**Smart Manufacturing and Materials** Rajeew Agrawal,Jinesh Kumar Jain,Vinod Singh Yadav,Vijaya Kumar Manupati,Leonilde Varela,2021-07-22 This book presents select proceedings of the International Conference on Evolution in Manufacturing ICEM 2020 and examines a range of areas including internet of things for cyber manufacturing data analytics for manufacturing systems and processes and materials The topics covered include modeling simulation and decision making

in cyber physical systems for supporting engineering and production management innovative approach in materials development biomaterial applications and advancement in manufacturing and material technologies The book also discusses sustainability in manufacturing and supply chain management including circular economy The book will be a valuable reference for beginners researchers and professionals interested in smart manufacturing in engineering production management and materials technology

**Recent Advances in Layered Materials and Structures** Sarmila

Sahoo,2021-02-22 This book provides topical information on innovative structural and functional materials and composites with applications in various engineering fields covering the structure properties manufacturing process and applications of these materials It covers various topics in layered structures and layered materials It discusses the latest developments in the materials engineering field This book will be useful for academicians researchers and practitioners working in the fields of materials engineering layered structures and composite materials

**Recent Advances in Complex Functional**

**Materials** Elson Longo,Felipe de Almeida La Porta,2017-07-12 In this book we explore new approaches to understanding the physical and chemical properties of emergent complex functional materials revealing a close relationship between their structures and properties at the molecular level The primary focus of this book is on the ability to synthesize materials with a controlled chemical composition a crystallographic structure and a well defined morphology Special attention is also given to the interplay of theory simulation and experimental results in order to interconnect theoretical knowledge and experimental approaches which can reveal new scientific and technological directions in several fields expanding the versatility to yield a variety of new complex materials with desirable applications and functions Some of the challenges and opportunities in this field are also discussed targeting the development of new emergent complex functional materials with tailored properties to solve problems related to renewable energy health and environmental sustainability A more fundamental understanding of the physical and chemical properties of new emergent complex functional materials is essential to achieving more substantial progress in a number of technological fields With this goal in mind the editors invited acknowledged specialists to contribute chapters covering a broad range of disciplines

Composite Materials Erian A. Armanios,1997

*Recent Advances in Engineering Design* Chetan Kumar Hirwani,Anindya Malas,Subrata Kumar Panda,Susmita Naskar,2025-11-01 This book comprises the proceedings of the 1st International Conference on Recent Advances in Design and Manufacturing RADM 2024 The contents of this volume focus on recent technological advances in the field of engineering design Some of the topics covered include Advanced Numerical Techniques Dynamics and Control of Structures Finite Element Analysis Fracture and Failure Mechanics Solid Mechanics Tribology Nano mechanics and MEMS Vibrations etc This volume will prove a valuable resource for those in academia and industry The book will be a valuable reference for beginners researchers and professionals interested in engineering design

*Recent Advances in Materials and Manufacturing Technology* Ramesh

Kumar Nayak,Mohan Kumar Pradhan,Animesh Mandal,J. Paulo Davim,2023-07-04 This book presents the select proceedings

of the 2nd International Conference on Advances in Materials and Manufacturing Technology ICAMMT 2022 The book covers the latest trends in existing and new materials manufacturing processes evaluation of materials properties for the application in automotive aerospace marine locomotive automotive and energy sectors The topics covered include advanced metal forming bending welding and casting techniques recycling and re manufacturing of materials and components materials processing characterization and applications multi physics coupling simulation and optimization alternate materials material substitution thermally enhanced processes and materials composites and polymer manufacturing powder metallurgy and ceramic forming numerical modeling and simulation advanced machining processes functionally graded materials non destructive examination optimization techniques engineering materials heat treatment material testing MEMS integration energy materials bio materials metamaterials metallography nanomaterial SMART materials and super alloys In addition it discusses industrial applications and covers theoretical and analytical methods numerical simulations and experimental techniques in the area of advanced materials and their applications It also covers the application of artificial intelligence in advanced materials and manufacturing technology The book will be a valuable reference for researchers and industry professionals alike

**Recent Advances in Textile Composites** Christophe Binetruy, François Boussu, 2010 [Advances in Composite Materials and Mechanics](#) Arup Maji, 1999 This collection contains 10 papers presented at a conference on composite materials and mechanics held in La Jolla California May 17 20 1998 WorkArea edit.aspx menuItemType Edit menuItemType Workarea close false LangType 1033 id 2147486946 type update back\_file content.aspx back\_action View back\_folder\_id 2147484230 back\_id 2147486946 back\_callerpage content.aspx back\_origurl action ViewContentByCategory id 2147484230 treeViewId 0 currentpage 1 back\_LangType 1033 officeInstalled False pullapproval false dvMetadata

[Fiber-Reinforced Composites - Recent Advances, New Perspectives and Applications](#) Longbiao Li, 2024-09-18 Fiber reinforced composites have been widely applied in different industrial areas This book focuses on the recent advances new perspectives and applications of different fiber reinforced composites such as ceramic matrix composites fiber reinforced concrete wood plastic composites and so on The design fabrication and application of fiber reinforced composites are related to the high mechanical properties and nondestructive damage monitoring techniques The experimental and damage monitoring method can reveal the internal damage evolution process inside of the fiber reinforced composites and improve the operation reliability and safety of the composites and components The book can help composite researchers better understand the engineering application mechanical behavior and damage detection of fiber reinforced composites [Recent Advances in Intrinsically Conducting Polymers and Composites](#) Bluma Guenther Soares, Sébastien Livi, Guilherme Mariz de Oliveira Barra, 2020-09-18 This eBook is a collection of articles from a Frontiers Research Topic Frontiers Research Topics are very popular trademarks of the Frontiers Journals Series they are collections of at least ten articles all centered on a particular subject With their unique mix of varied contributions from Original Research to Review Articles Frontiers Research

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**Recent Advances in Nano-Tailored Multi-Functional Cementitious Composites** Mustafa Şahmaran, Faiz Shaikh, Gürkan Yıldırım, 2022-03-08 Over the past few years concrete technology has advanced quite dramatically thanks to the use of a great variety of additives and admixtures which have paved the way for the effective development of new generation concrete mixtures Among these additives and admixtures nanomaterials used in construction materials such as paste mortar and concrete mixtures have become very popular recently Much of the previous attention in regard to the utilization of nanomaterials in construction materials was specifically devoted to the characterization of their fresh state hydration microstructure pore structure mechanical transport and durability properties However research into the tailoring of multi functional properties of construction materials especially cementitious with the use of nanomaterials is still in its infancy Recent Advances in Nano Tailored Multi Functional Cementitious Composites aims to capture recent major scientific advances and the current state of the art in multi functional cementitious composites developed with nanomaterials The book will provide researchers engineers and other stakeholders with an insight into future directions of multi functional capabilities of cementitious composites Chapters focus on the large scale development characterization and application of multi functional cementitious composites addressing the following topics nano modified concrete strain hardening cementitious composites self sensing concrete self healing and bacteria based concrete self cleaning concrete self consolidating concrete material construction technology for 3D printing thermal insulation capability green concretes including geopolymers concrete nanoscale characterization methods low CO<sub>2</sub> reactive magnesia cements and future developments and challenges of nano tailored cementitious composites The book will be an essential reference resource for academic and industrial researchers materials scientists and civil engineers working on the development and application of nano tailored multi functional cementitious composites Provides very comprehensive and unique details about multi functional properties of cementitious composites Presents a detailed account of investigations conducted into the application of nanomaterials and nanoscale tailoring to achieve multi functional properties for cementitious composites Features state of the art preparation production processing and implementation techniques of nanoscale tailoring of multi functional cementitious composites starting from laboratory to large scale

**Recent Advances in Material, Manufacturing, and Machine Learning** Bjorn Schuller, Rajeev Gupta, Rakesh Mote, Abhishek Sharma, J.P. Giri, R.B. Chadge, 2024-06-17 The main aim of the 2nd international conference on recent advances in materials manufacturing and machine learning processes 2023 RAMMML 23 is to bring together all interested academic researchers scientists engineers and technocrats and provide a platform for continuous improvement of manufacturing machine learning design and materials engineering research RAMMML 2023 received an overwhelming response with more than 530 full paper submissions After due and careful

scrutiny about 120 of them have been selected for presentation The papers submitted have been reviewed by experts from renowned institutions and subsequently the authors have revised the papers duly incorporating the suggestions of the reviewers This has led to significant improvement in the quality of the contributions Taylor Francis publications CRC Press have agreed to publish the selected proceedings of the conference in their book series of Advances in Mechanical Engineering and Interdisciplinary Sciences This enables fast dissemination of the papers worldwide and increases the scope of visibility for the research contributions of the authors



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