



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 CO₂ 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

E.E. Gdoutos, Anthony N. Kounadis



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 and Structures, Volume 1 Himanshu Pathak, Sunny Zafar, 2025-10-29 This book includes the select proceedings of the International Conference on Composites Design Processing Manufacturing and Health Monitoring CDPMHM 2024 It covers latest research in designing processing manufacturing and health monitoring techniques for composite materials and structures The topics covered in this book are additive manufacturing design against fatigue crack growth and fracture composites for bio medical applications electrical vehicles space and aero space applications and many more The book is a valuable reference for researchers and professionals interested in composite material and structure allied fields **Recent Advances in Composites Engineering and Research** Mulakaluri Rama

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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 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 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 Smart Self-healing Polymers and Composites Guoqiang Li,2015-06-01 Recent Advances in Smart Self Healing Polymers and Composites examines the advances made in smart materials over the last few decades and their significant applications in aerospace automotive civil mechanical medical and communication engineering fields Based on a thorough review of the literature the book identifies smart self healing polymers and composites as one of the most popular challenging and promising areas of research Readers will find valuable information compiled by a large pool of researchers who not only studied the latest datasets but also reached out to leading contributors for insights and forward thinking analogies Examines the advances made in smart materials over the last few decades Presents significant applications in aerospace automotive civil mechanical medical and communication engineering fields Compiled by a large pool of researchers who not only studied the latest datasets but also reached out to leading contributors for insights and forward thinking analogies

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optimization artificial neural networks and evaluation This book will be useful for researchers and professionals working in the field of health monitoring of engineering structures

Recent Advances in Functional Materials, Volume 1 Manish Kumar, Anjani Kumar Singh, Subhash Sharma, Devendra Kumar, 2025-09-19 This volume presents the select proceedings of International Conference on Recent Advances in Functional Materials RAFM 2024 It covers a wide range of topics such as multifunctional materials 2D materials biomaterials materials for environmental studies DFT and solar simulation of materials perovskite and double perovskite materials luminescent materials smart materials materials for energy conversion and storage smart materials advanced functional materials polymeric materials composites liquid crystals materials for sustainable development nanomaterials and thin films smart devices and quantum dots synthesis technique and characterization tools with application in smart devices The book will be useful for researchers and professionals working in various areas of materials science

Recent Advances in Mechanics of Functional Materials and Structures Poonam Kumari, Santosha Kumar Dwivedy, 2024-08-23 This book comprises the select peer reviewed proceedings of the 8th Asian Conference on Mechanics of Functional Materials and Structures ACMFMS 2022 It aims to provide a comprehensive and broad spectrum picture of the state of the art research and development in diverse areas such as contact mechanics biomechanics and biomaterials fracture and damage mechanics impact mechanics and dynamic materials structural health monitoring and mechanics of functional and smart structures among others This book is a valuable resource for researchers and professionals working in academia and industry in the areas of mechanical engineering

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

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Recent Advances in Mechanics E.E. Gdoutos, Anthony N. Kounadis, 2011-01-19 This book contains 24 papers presented at the symposium on Recent Advances in Mechanics dedicated to the late Professor Academician Pericles S Theocaris in commemoration of the tenth anniversary of his death The papers are written by world renowned and recognized experts in their fields and serve as a reference and guide for future research The topics covered in the book can be divided into three major themes Mathematical methods in applied mechanics nine papers experimental mechanics nine papers and fracture mechanics six papers Topics covered include Application of reciprocity relations to laser based ultrasonics boundary value problems of the theory of elasticity optimal design in contact mechanics scaling of strength and lifetime distributions of quasibrittle structures directional distortional hardening in plasticity vibration of systems instability phenomena in damped systems variational methods for static and dynamic elasticity problems an accelerated Newmark scheme for solving the equations of motion in the time domain photoelastic tomography electronic speckle pattern interferometry composites exposed to fire sampling moir microelectromechanical systems experimental mechanics in nano scale advanced cement based nanocomposites piezonuclear transmutations in brittle rocks under mechanical loading stress triaxiality at crack tips studied by caustics reinforcement of a cracked elastic plate with defects some actual problems of fracture mechanics cyclic plasticity with applications to extremely low cycle fatigue of structural steel and fracture of a highly filled polymer composite

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

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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

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