

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

Himanshu Pathak, Sunny Zafar



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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 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

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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

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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 the June 23-28, 2002 in conjunction with the 14th 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 moiré 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 nondestructive evaluation neutron diffraction and synchrotron radiation methods hybrid methods composite structures and structural testing and analysis

Hybrid Composite Materials Akarsh Verma, Hariome Sharan Gupta, Sushanta K. Sethi, 2024-05-18 The aim of this book is to provide readers with a better understanding of the experimental methods and computational modeling techniques employed in the characterizations of diverse hybrid composite

materials It covers the mechanisms important aspects characteristics formulations significant elements and case studies of the hybrid composite materials used in a wide range of applications To inspire researchers the most recent studies in the field as well as potential directions for more study are also emphasized

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

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