



Friction welding of dissimilar plastic/polymer materials with metal powder reinforcement for engineering applications

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ABSTRACT

Friction welding is one of the established processes for joining of similar as well as dissimilar polymer/plastics and metals. In past 20 years numbers of application in different areas using this process have been highlighted, but very limited contributions have been reported on properties of friction welded joints of dissimilar polymer/plastic materials after reinforcement with metal powder. In the present work an attempt has been made to perform friction welding of dissimilar plastic based materials by controlling the melt flow index (MFI) after reinforcement with metal powder. The present studies of friction welding for dissimilar plastic were performed on Lathes by considering three input parameters (namely: rotational speed, feed rate, and time taken to perform welding). Investigations were made to check the influence of process parameters on mechanical and metallurgical properties (like: tensile strength, Shore D hardness and porosity at joint). The process parameters were optimized using Minitab software based on Taguchi L9 orthogonal array and results are supported by photomicrographs.

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1. Introduction

The joining of composite materials and structures is a topic of high technological interest; since it is well known that traditional joining techniques are usually not directly exportable to composite elements (refer, e.g. to [1–4] and references therein). Attention is increasingly being given to the following research areas, both experimentally and numerically: fusion bonding [5,6]; welding-based joining techniques [7–14]; friction spot and friction lap joining [15,16]; and ultrasonic joining [17]. Friction welding is a process of joining of materials and structures below their melting points. When these materials come in contact with relative motion to each other, with the action of friction, heat is produced and deformation takes place, due to this intermolecular diffusion is occurred between their faces and thus welding is performed. Friction welding concept was originally come for similar metal joining, but it was further applied for similar thermoplastic composites [18]. Later on this concept was used for the dissimilar materials like steel-aluminum and steel-copper and aluminum-magnesium cylindrical piece joining [19,20] and for dissimilar plastic welding of ABS to

HDPE [21]. The number of studies has been reported to check the mechanical, thermal and metallurgical properties of friction welded piece [22–24]. Interface properties are examined to check the fusion, deformation mechanisms and microstructure characteristics of friction welded interface [20,25–26]. ABS and Nylon6 are commonly used thermoplastics with excellent mechanical properties and are used generally for friction welding application [21]. The joining of ABS or Nylon 6 to itself or welding of ABS to HDPE is feasible [27], but, there is a limitation of joint strength (for friction welded joints) of these thermoplastics that hinders its use in different engineering applications.

Some studies have highlighted the use of a tool in the form of a ring which is rotated in between the interface of two pipes. This is getting heated deformed by friction created due to rotation of ring, so welding of pipeline is possible [28]. Friction inertia welding concept is widely accepted in aerospace applications [29,30]. Reinforcement of polymer with nano-composite is the technique to make the feasibility of friction welding process. The studies also highlight that friction spot welding of polymethyl-methacrylate and polymethyl-methacrylate-SiO₂ is feasible [31]. The reinforcement of nano-composite with polymers is responsible for the improved mechanical and metallurgical properties [32–36].

The literature review reveals that joint strength properties of friction welded joints of ABS with Nylon6 are not good enough

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Friction Welding Of Dissimilar Plastic Polymer Materials

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Encyclopedia of Renewable and Sustainable Materials ,2020-01-09 Encyclopedia of Renewable and Sustainable Materials Five Volume Set provides a comprehensive overview covering research and development on all aspects of renewable recyclable and sustainable materials The use of renewable and sustainable materials in building construction the automotive sector energy textiles and others can create markets for agricultural products and additional revenue streams for farmers as well as significantly reduce carbon dioxide CO2 emissions manufacturing energy requirements manufacturing costs and waste This book provides researchers students and professionals in materials science and engineering with tactics and information as they face increasingly complex challenges around the development selection and use of construction and manufacturing materials Covers a broad range of topics not available elsewhere in one resource Arranged thematically for ease of navigation Discusses key features on processing use application and the environmental benefits of renewable and sustainable materials Contains a special focus on sustainability that will lead to the reduction of carbon emissions and enhance protection of the natural environment with regard to sustainable materials **Advances in Welding**

Technologies for Process Development Jaykumar Vora,Vishvesh J. Badheka,2019-02-22 Within manufacturing welding is by far the most widely used fabrication method used for production leading to a rise in research and development activities pertaining to the welding and joining of different similar and dissimilar combinations of the metals This book addresses recent advances in various welding processes across the domain including arc welding and solid state welding process as well as experimental processes The content is structured to update readers about the working principle predicaments in existing process innovations to overcome these problems and direct industrial and practical applications Key Features Describes recent developments in welding technology engineering and science Discusses advanced computational techniques for procedure development Reviews recent trends of implementing DOE and meta heuristics optimization techniques for setting accurate parameters Addresses related theoretical practical and industrial aspects Includes all the aspects of welding such as arc welding solid state welding and weld overlay *Additive and Subtractive Manufacturing of Composites* Sanjay Mavinkere Rangappa,Munish Kumar Gupta,Suchart Siengchin,Qinghua Song,2021-08-06 This book describes crucial aspects related to the additive and subtractive manufacturing of different composites The first half of this book mainly deals with the various types of composite fabrication methods along with the introduction features and mechanisms and also the processing of composite materials via additive manufacturing route Also the thermal mechanical physical and chemical properties relevant to the processing of composite materials are included in the chapters The second half of this book primarily demonstrates an extensive section on the different types of additive manufacturing processes like selective laser sintering selective laser melting stereolithography fused deposition modeling and material jetting used to fabricate the metals and polymers Also the chapters address the complete description of fabrication processes for metal matrix composites and

polymer matrix composites Moreover the different methods adopted such as short peening micro machining heat treatment and solution treatment to improve the surface improvement are well discussed This book gives many helps to researchers and students in the fields of the additive and subtractive manufacturing of different composites *Futuristic Composites*

Sarabjeet Singh Sidhu,Preetkanwal Singh Bains,Redouane Zitoune,Morteza Yazdani,2018-09-26 This book presents a collection of chapters on various aspects of futuristic composite materials from manufacturing challenges to materials characterization The book covers the scientific basis of processing and synthesizing futuristic composites including the prerequisite theoretical background and latest fabrication techniques The book also discusses industrial applications of composites such as in aerospace automotive and sports equipment This book will serve as a valuable guide for researchers and professionals working in the area of futuristic lightweight materials **Material Forming** Pierpaolo Carlone,Luigino Filice,Domenico Umbrello,2025-06-05

The ESAFORM 2025 proceedings covers 280 papers on a wide range of topics including Additive Manufacturing Composites Forming Processes Extrusion and Drawing Forging and Rolling Formability of Metallic Materials Friction and Wear in Metal Forming Incremental and Sheet Metal Forming Innovative Joining by Forming Technologies Optimization and Inverse Analysis in Forming Machining Cutting and Severe Plastic Deformation Processes Material Behavior Modelling New and Advanced Numerical Strategies for Material Forming Non Conventional Processes Polymer Processing and Thermomechanical Properties and Sustainability in Material Forming Keywords Additive Manufacturing Composites Forming Processes Extrusion and Drawing Forging and Rolling Formability of Metallic Materials Friction and Wear in Metal Forming Incremental and Sheet Metal Forming Innovative Joining by Forming Technologies Optimization and Inverse Analysis in Forming Machining Cutting and Severe Plastic Deformation Processes Material Behavior Modelling New and Advanced Numerical Strategies for Material Forming Non Conventional Processes Polymer Processing and Thermomechanical Properties and Sustainability in Material Forming **The Chemistry of Environmental Engineering** Johannes Karl Fink,2020-04-07

The focus of this book is the chemistry of environmental engineering and its applications with a special emphasis on the use of polymers in this field It explores the creation and use of polymers with special properties such as viscoelasticity and interpenetrating networks examples of which include the creation of polymer modified asphalt as well as polymers with bacterial adhesion properties The text contains the issues of polymerization methods recycling methods wastewater treatment types of contaminants such as microplastics organic dyes and pharmaceutical residues After a detailed overview of polymers in Chapter 1 their special properties are discussed in the following chapter Among the topics is the importance of polymers to water purification procedures since their use in the formation of reverse osmosis membranes do not show biofouling Chapter 3 details special processing methods such as atom transfer radical polymerization enzymatic polymerization plasma treatment and several other methods can be used to meet the urgent demands of industrial applications Chapter 4 addresses the important environmental issue of recycling methods

as they relate to several types of materials such as PET bottles tire rubbers asphalt compositions and other engineering resins And wastewater treatment is detailed in Chapter 5 in which the types of contaminants such as microplastics organic dyes and pharmaceutical residues are described and special methods for their proper removal are detailed along with types of adsorbents including biosorbents Still another important issue for environmental engineering chemistry is pesticides Chapter 6 is a thorough description of the development and fabrication of special sensors for the detection of certain pesticides A detailed presentation of the electrical uses of polymer based composites is given in Chapter 7 which include photovoltaic materials solar cells energy storage and dielectric applications light emitting polymers and fast charging batteries And recent issues relating to food engineering such as food ingredient tracing protein engineering biosensors and electronic tongues are presented in Chapter 8 Finally polymers used for medical applications are described in Chapter 9 These applications include drug delivery tissue engineering porous coatings and also the special methods used to fabricate such materials

Advances in Additive Manufacturing and Joining M. S. Shunmugam, M. Kanthababu, 2019-10-16 This volume presents research papers on additive manufacturing popularly known as 3D printing and joining which were presented during the 7th International and 28th All India Manufacturing Technology Design and Research conference 2018 AIMTDR 2018 The contents of this volume present the latest technological advancements for improving the efficiency accuracy and speed of the additive manufacturing process and in fusion and solid state welding technologies with a variety of technologies including fused deposition modelling poly jet 3D printing weld deposition based technology selective laser melting and important welding technologies being covered This volume will be of interest to academicians researchers and practicing engineers alike

Fundamentals and Advances in Metal Matrix Composites Tharmaraj Ramakrishnan, PM Gopal, 2025-06-10 The scope of this book covers the fundamental background of metal matrix composites MMCs their processing and fabrication testing and characterization exploration of materials for MMCs and green MMCs and advancements in all aspects of fabrication testing and applications Development or fabrication of MMCs with evaluation of mechanical and tribological properties as well as machinability evaluation optimization of fabrication process and machining operations are covered Features Covers advanced processing strategies and machining studies for composite materials Discusses representative volume element based FEM modelling approaches and sustainability Sheds light on advancements in MMC application fabrication and testing Reviews green MMCs and sustainability in MMCs development Includes case studies and intelligent modelling methodologies This book is aimed at graduate students researchers and professionals in micro nanoscience and technology mechanical engineering industrial engineering metallurgy and composites

Advances in Materials Processing Sunpreet Singh, Chander Prakash, Seeram Ramakrishna, Grzegorz Krolczyk, 2020-06-22 This book presents the select proceedings of the International Conference on Functional Material Manufacturing and Performances ICFMMP 2019 The book primarily covers recent research theories and practices relevant to surface engineering and

processing of materials It focuses on the lesser known technologies and advanced manufacturing methods which may not be standardized yet but are highly beneficial to material and manufacturing industrial engineers The book includes current advances in the field of coating deposition cladding nanotechnology surface finishing precision machining processing and emerging advanced manufacturing technologies which enhance the performance of materials in terms of corrosion wear and fatigue The book can be a valuable reference for beginners researchers and professionals interested in materials processing and allied fields

Additive Manufacturing Rupinder Singh,J. Paulo Davim,2018-09-13 There has been a great deal of progress in additive manufacturing AM during the past two decades and recent developments have been highlighted by many researchers However until now there has been a limit to what is available for beginners in a step by step format showcasing the different commercial AM technologies for field application This book helps fill that gap Additive Manufacturing Applications and Innovations presents case studies of commonly used AM technologies with basic numerical problems for better understanding It also includes hybrid processes and 4D printing applications which currently are not offered in other AM books Features Offers solved and unsolved problems in additive manufacturing Provides an understanding for additive manufacturing per international standards Includes case studies for better understanding of the individual processes Presents a review of specific technology highlights Introduces future research directions mainly in 4D printing applications

Joining Processes for Dissimilar and Advanced Materials Pawan Kumar Rakesh,J. Paulo Davim,2021-11-13 Joining Processes for Dissimilar and Advanced Materials describes how to overcome the many challenges involved in the joining of similar and dissimilar materials resulting from factors including different thermal coefficients and melting points Traditional joining processes are ineffective with many newly developed materials The ever increasing industrial demands for production efficiency and high performance materials are also pushing this technology forward The resulting emergence of advanced micro and nanoscale material joining technologies have provided many solutions to these challenges Drawing on the latest research this book describes primary and secondary processes for the joining of advanced materials such as metals and alloys intermetallics ceramics glasses polymers superalloys electronic materials and composites in similar and dissimilar combinations It also covers details of joint design quality assurance economics and service life of the product Provides valuable information on innovative joining technologies including induction heating of metals ultrasonic heating and laser heating at micro and nanoscale levels Describes the newly developed modelling simulation and digitalization of the joining process Includes a methodology for characterization of joints

Post-Processing of Parts and Components Fabricated by Fused Deposition Modeling Vinayak R. Malik,Vivek Kumar Tiwary,Arunkumar Padmakumar,2024-11-15 This book describes several post processing techniques that can be used to enhance the mechanical strength isotropy surface quality and dimensional accuracy of 3D printed components using the Fused Deposition Modeling FDM technique It also discusses the usage of adhesives interlocks fasteners ultrasonic frictional and microwave energy to join FDM 3D printed parts Furthermore

the book also covers the scope of future research and challenges in the post processing of FDM parts as well as some of the most popular approaches in the field such as Big Area Additive Manufacturing BAAM Machine Learning and Internet of Things IoT Features Covers all necessary details related to post processing of Fused Deposition Modeling FDM parts Provides an overview of various joining techniques for 3D printed FDM parts Focuses on the latest developments related to sustainability and optimization in post processing of FDM parts Includes microwave joining of 3D printed parts Reviews case studies on cutting edge research innovation and development aspects This book is aimed at researchers and graduate students in additive manufacturing materials science as well as manufacturing engineering

Friction Stir Welding and Processing X Yuri Hovanski, Rajiv Mishra, Yutaka Sato, Piyush Upadhyay, David Yan, 2019-02-11 This book is a compilation of the recent progress on friction stir technologies including high temperature applications industrial applications dissimilar alloy materials lightweight alloys simulation control characterization and derivative technologies The volume offers a current look at friction stir welding technology from application to characterization and from modeling to R D Contributions document advances in application controls and simulation of the friction stir process to aid researchers in seeing the current state of the art *2nd International Conference on Mechanical, Manufacturing and Process Plant Engineering* Mokhtar Awang, 2017-04-28 This volume presents selected papers from the 2nd International Conference on Mechanical Manufacturing and Process Plant Engineering ICMMPPE 2016 which was held from 23rd to 24th November 2016 in Kuala Lumpur Malaysia The proceedings discuss genuine problems of joining technologies that are heart of manufacturing sectors It discusses the findings of experimental and numerical works from soldering arc welding to solid state joining technology that faced by current industry

Handbook of Research on Advancements in the Processing, Characterization, and Application of Lightweight Materials Kumar, Kaushik, Babu, B. Sridhar, Davim, J. Paulo, 2021-11-19 In the automotive industry the need to reduce vehicle weight has given rise to extensive research efforts to develop aluminum and magnesium alloys for structural car body parts In aerospace the move toward composite airframe structures urged an increased use of formable titanium alloys In steel research there are ongoing efforts to design novel damage controlled forming processes for a new generation of efficient and reliable lightweight steel components All these materials and more constitute today's research mission for lightweight structures They provide a fertile materials science research field aiming to achieve a better understanding of the interplay between industrial processing microstructure development and the resulting material properties The Handbook of Research on Advancements in the Processing Characterization and Application of Lightweight Materials provides the recent advancements in the lightweight materials processing manufacturing and characterization This book identifies the need for modern tools and techniques for designing lightweight materials and addresses multidisciplinary approaches for applying their use Covering topics such as numerical optimization fatigue characterization and process evaluation this text is an essential resource for materials engineers manufacturers practitioners engineers

academicians chief research officers researchers students and vice presidents of research in government industry and academia

Proceedings of The International Conference on Material Science Reshmy Rajasekharan, Sindhu Raveendran, Libin P. Oommen, 2025-07-15 The proceedings of MatZone 2024 encompasses cutting edge research in nanomaterials and biomaterials highlighting their interdisciplinary applications in sciences engineering biomedical packaging environmental and health sectors Topics include biocomposites for advanced electronic and optical devices tissue engineering scaffolds and environmental solutions like dye and heavy metal removal Special attention is given to biotechnological advancements that promote human life sustainability Emerging materials such as cellulose chitosan PLA PHB and other bio derived composites are emphasized along with innovative techniques like membrane studies chromatographic separation and biosensor development The proceedings offer a comprehensive insight into the current trends and future directions in biomaterials research

Advances in Welding Metal Alloys, Dissimilar Metals and Additively Manufactured Parts Giuseppe Casalino, 2018-11-29 This book is a printed edition of the Special Issue Advances in Welding Metal Alloys Dissimilar Metals and Additively Manufactured Parts that was published in Metals

Friction Stir Welding and Processing Sandeep Rathee, Manu Srivastava, J. Paulo Davim, 2024-03-25 A single source of information on the fundamental concepts and latest research applications of friction stir welding and processing Friction Stir Welding and Processing Fundamentals to Advancements provides concise yet comprehensive coverage of the field of friction stir welding with an eye toward future research directions and applications Throughout the book case studies provide real world context and highlight applications for various engineering sectors With contributions from an array of leaders in the field Friction Stir Welding and Processing provides readers with a single source of information on all aspects of FSW and FSP After explaining the fundamentals of friction stir welding FSW and its variants the book discusses composite fabrication techniques using friction stir processing FSP Different types of friction techniques are covered as is the equipment used Detailed characterization of samples and composites are included Additional topics discussed include the impact of FSW on the economics of production methods for coupling FSW FSP with additive manufacturing composite fabrication and process property relationships Master the basic concepts of friction stir welding and its variants Discover the role of FSW in developing hybrid manufacturing techniques Follow case studies that connect theoretical concepts to real world experimental results Learn from contributions from an array of global thought leaders in the field This is a valuable compendium on the topic for engineers and designers who utilize welding and advanced manufacturing across industries as well as graduate students and post graduate researchers who are exploring new friction stir welding applications

Advanced Joining Processes Lucas F. M. da Silva, Mohamad S. El-Zein, Paulo A.F. Martins, 2020-10-31 Advanced Joining Processes Welding Plastic Deformation and Adhesion brings together a range of advanced thermal mechanical and chemical methods of joining offering an up to date resource for those looking to understand and utilize the very latest techniques

Efficient joining techniques are critical to a range of innovative applications with technology in constant development. The first section of the book provides in depth information on advanced welding techniques including friction stir, explosive, ultrasonic, laser, electron beam, and computational weld analysis and fatigue of structures. The second section highlights key developments in joining by plastic deformation, adhesive bonding, and hybrid joining. The coverage of each technique is supported by practical guidance, detailed analysis, and finite element simulations. This is an essential reference for researchers and advanced students in joining, welding, adhesion, materials processing, mechanical engineering, plastics engineering, manufacturing, civil engineering, and automotive/aerospace engineering, as well as engineers, scientists, and R D professionals using joining, welding, and adhesion methods across a range of industries. Presents the latest research findings and developments across welding, joining by plastic deformation, and adhesion. Includes state of the art methods such as laser, ultrasonic, and electron beam welding, hybrid joining, and the use of electromagnetic pulses. Offers practical guidance, detailed analysis, and finite element simulations for all techniques covered.

Advanced Manufacturing Technologies Kapil Gupta, 2017-04-29. This book provides details and collective information on working principle, process, mechanism, salient features, and unique applications of various advanced manufacturing techniques and processes. The book is divided in three sessions covering modern machining methods, advanced repair, and joining techniques, and finally sustainable manufacturing. The latest trends and research aspects of those fields are highlighted.

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