



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



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## ARTICLE INFO

### Article history:

Received 28 May 2016

Accepted 30 June 2016

Available online 4 July 2016

### Keywords:

Friction welding

ABS

Nylon6

Shore hardness

Tensile strength

Porosity

## 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 Lathe 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-SiO<sub>2</sub> 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

**S Marginson**



## **Friction Welding Of Dissimilar Plastic Polymer 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

**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

**Futuristic Composites** Sarabjeet Singh Sidhu, Preetkanwal Singh Bains, Redouane Zitoun, 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

**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 shot 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

**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

**Plastics Products Design Handbook** Miller, 1983-12-06 This book provides information on complexities peculiarities and limitations of various molding processes and the comparative advantages and disadvantages of the possible plastic products manufacturing techniques to permit an ideal match of good design and processing

**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 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

*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

**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

Fixing and Fastening: Joining of Plastics 99 Rapra Technology,iSmithers Rapra Publishing,1999

Energy in Plastics Technology Wolfgang Kaiser,Willy Schlachter,2023-09-11 Energy in Plastics Technology provides unlike any other book the necessary fundamentals for dealing with thermotechnical issues in the processing of plastics leading to efficient robust reliable economical and environmentally friendly processes for high quality products The following four areas are addressed Methodical application of the essential fundamentals to practical problems The focus is on the formulation of energy balances Special emphasis is placed on the understanding of the first and second laws of thermodynamics with their manifold implications Access to key advanced technical literature which can be highly theoretical and forms the basis for advanced simulation methods is provided Analytical approaches for modeling processes as opposed to numerical simulation methods are covered so that the influence of the essential process parameters can be better recognized and correct results in terms of order of magnitude are obtained with reasonable effort These simplified considerations provide a valuable support for the preparation of experiments and numerical simulations and their critical evaluation The fundamentals provided are applied in exemplary calculation examples to problems relevant to practice in the most important

processing and forming methods The book is aimed at engineers and students working in plastics technology as well as technicians and plastics technologists Contents Part 1 Introductory Fundamentals Introduction Material Behavior of Plastics Thermodynamics Fluid Mechanics I Heat Transfer Part 2 Advanced Fundamentals Steady State Heat Conduction Transient Heat Conduction Thermodynamics of Air Drying Fluid Mechanics II Recycling of Plastics Part 3 Practical Examples

**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 Modern Manufacturing Processes for Aircraft Materials

Selim Gorgen, Catalin I. Pruncu, 2023-11-03 Approx 530 pages Provides detailed explanation of modern manufacturing processes used in the aircraft industry Covers additive manufacturing both for polymeric and metallic materials electrical discharge machining laser welding electron beam welding and micro machining Explains manufacturing operations for not only metallic materials but also polymers and composites **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     **Plastic Processes** Mr. Rohit Manglik, 2024-01-23 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels     Plastics in Medical Devices Vinny R. Sastri, 2010-03-05 No book has been published that gives a detailed description of all the types of plastic materials used in medical devices the unique requirements that the materials need to comply with and the ways standard plastics can be modified to meet such needs This book will start with an introduction to medical devices their classification and some of the regulations both US and global that affect their design production and sale A couple of chapters will focus on all the requirements that plastics need to meet for medical device applications The subsequent chapters describe the various types of plastic materials their properties profiles the advantages and disadvantages for medical device applications the techniques by which their properties can be enhanced and real world examples of their use Comparative tables will allow readers to find the right classes of materials suitable for their applications or new product development needs

**Proceedings of the 1st International Joint Symposium on Joining and Welding** H. Fujii, 2014-08-27 This book contains the papers from the Proceedings of the 1st international joint symposium on joining and welding held at Osaka University Japan 6 8 November 2013 The use of frictional heating to process and join materials has been used for many decades Rotary and linear friction welding are vital techniques for many industrial sectors More recently the development of friction stir welding FSW has significantly extended the application of friction processing This conference is the first event organized by the three major institutes for joining and welding to focus on the broad range of friction processes This symposium will provide the latest valuable information from academic and industrial experts from around the world on FSW FSP linear and rotary friction welding



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grease is a 1978 american musical romantic comedy film directed by randal kleiser in his feature directorial debut from a screenplay by bronté woodard and an adaptation by allan carr based on the stage musical of the same name by jim jacobs and warren casey

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aug 14 1998 Özet 1950 lerde geçen filmin öyküsü bir grup liseli amerikan gencinin gündelik hayatlarını müzikli ve neşeli bir şekilde anlatır Öykünün merkezinde danny ve sandy nin ilişkisi vardır danny ve sandy yaz tatillerinde birbirlerini tanımış ve aşk yaşamış bir çifttir

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grease danny zuko ve sandy olsson kusursuz bir yaz aşkı yaşamıştır yaz biter ve ikili okullarına başlamak üzere ayrılırlar danny rydell deki ilk gününde cool deri ceketli serseri çetesi t birds ün başına döner

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