



# Abrasive machining of advanced aerospace alloys and composites

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## ARTICLE INFO

**Keywords:**  
Abrasion  
Grinding  
Material removal

## ABSTRACT

The aerospace industry has experienced significant growth over the past decade and it is estimated that nearly 30,000 new commercial passenger aircraft will be required by 2030 to meet rising global demand. Abrasive machining is a key material removal process utilised in the production of aeroengine components. Current industrial practice and perspectives relating to grinding in the aerospace sector are presented including general workpiece surface integrity standards/requirements, fluid delivery systems, wheel preparation options and machine tool design/configurations. Corresponding academic research on the machinability of aerospace alloys and composites are critically reviewed together with recent developments involving novel/innovative grinding processes.

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## 1. Introduction

The worldwide market for civil aircraft is rising in line with increasing global population and affluence. Growth in new airplane deliveries is expected to be at an average of 3.6% per annum up to 2030 [114]. This naturally translates to a greater demand for gas turbine engines, which places significant strains on current as well as future supply chain and production capacity.

Commercial pressures for continuous improvement in aeroengine performance and fuel efficiency have driven the development of materials with increasing temperature limits at affordable cost [85]. This is evident from the evolution of materials composition in engines, with the trend moving towards alloys with higher temperature capability (from steels to nickel and titanium alloys) and materials with lower density (aluminium to carbon fibre composites). Although not fully mature, ceramic and metal matrix composites (CMC and MMC) are showing evidence of replacing some of the high temperature alloys that dominated engines towards the end of the 20th century. The constantly changing state of aeroengine materials technology is another factor that will considerably stretch the limits/capability of established manufacturing processes and therefore further emphasises the critical need to develop more advanced and robust production techniques.

Despite the rapid development and increasing acceptance of non-conventional machining processes for the manufacture of

turbomachinery parts [123], grinding is still one of the primary operations in the finish machining of critical gas turbine engine components. This is due to the strict requirement for achieving tight dimensional tolerances of <10 µm and superior surface finish with roughness in the order of <0.5 µm Ra together with acceptable workpiece quality/integrity.

The keynote will discuss the latest developments in academic research together with current state-of-the-art relating to abrasive machinability of key aerospace alloys and composite materials, fluid delivery and wheel preparation strategies, machine tool technologies and innovative process configurations, as well as example case studies and perspectives from practitioners in the aeroengine manufacturing sector. The paper complements a sister keynote to be presented in STC-C relating to the 'High performance cutting of advanced aerospace materials' as well as the keynote delivered last year (2014) in STC-E [123].

## 2. Workpiece surface/sub-surface integrity requirements

Aeroengine discs are categorised as critical components and are therefore subject to highly stringent dimensional accuracy, surface integrity and fatigue requirements. It is well documented that the functional performance of parts subject to machining processes is strongly affected by the resulting material surface/subsurface integrity conditions [111]. Publications detailing investigations relating to the influence of material removal processes on workpiece residual stresses initially appeared in the 1950s. However, Field and Kahles [66] were the first to define the concept of surface integrity and propose associated methodologies

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E-mail address: [s.l.soo@bham.ac.uk](mailto:s.l.soo@bham.ac.uk) (S.L. Soo) [23].

# Abrasive Machining Of Advanced Aerospace Alloys And Composites

**Camilla Rothe**



## **Abrasive Machining Of Advanced Aerospace Alloys And Composites:**

**Advances in Sustainable Machining and Manufacturing Processes** Kishor Kumar Gajrani,Arbind Prasad,Ashwani Kumar,2022-05-18 This text provides an in depth overview of sustainability in machining processes challenges during machining of difficult to cut materials and different ways of green machining in achieving sustainability It discusses important topics including green and sustainable machining dry machining textured cutting coated tools for machining solid lubricants based machining gas cooled machining cryogenic cooling for intelligent machining artificial neural network for machining big data based machining and hybrid intelligent machining This book Covers advances in sustainable machining such as gas cooled machining near dry machining and minimum quantity lubrication Explores use of big data machine learning and artificial intelligence for machining processes Provides case studies and experimental design as well as results with analysis focusing on achieving sustainability Discusses artificial intelligence and machine learning based machining processes Cover the latest applications of sustainable manufacturing for a better understanding of the concepts The text is primarily written for senior undergraduate graduate students and researchers in the fields of mechanical manufacturing industrial production engineering and materials science [Proceedings of the 3rd Conference on Physical Modeling for Virtual Manufacturing Systems and Processes](#) Jan C. Aurich,Christoph Garth,Barbara S. Linke,2023-07-10 This is an open access book reporting the results of nine years research of the International Research Training Group IRTG 2057 funded by the German Research Foundation DFG The IRTG is a joint venture between the TU Kaiserslautern the University of California Berkeley and University of California Davis The book is content driven mainly by two disciplines engineering and computer science Through the application of scientific knowledge and advanced computer based methods in conjunction with physical models on a level unrealized in the past technologies and methods are promoted which can be used for planning and optimization of manufacturing systems and processes As a result fundamental understanding as well as extensive systems tools and computational algorithms which significantly improve the integration of advanced computational methods for solving problems of manufacturing systems and processes will be available This open access book is of interest to any researcher dealing with process and factory planning in manufacturing like for cutting and additive manufacturing

*Hybrid Manufacturing Processes* Wit Grzesik,Adam Ruszaj,2021-07-03 This book explores in a systematic way both conventional and unconventional material shaping processes with various modes of hybridization in relation to theory modelling and industrial potential The demand for high productivity and high accuracy in manufacturing is continuously increasing based on improvement and optimization strategies Hybridization of manufacturing processes will play a crucial role and will be of a key importance in achieving environmental and economical sustainability Structured in three parts Hybrid Manufacturing Processes summarizes the state of the art hybrid manufacturing processes based on available literature sources and production reports The book begins by providing information on the physical fundamentals of the

removal and non removal processes in macro micro and nanoscales It then follows with an overview of the possible ways of hybridization and the effects on the enhancement of process performance before concluding with a summary of production outputs related to surface integrity specifically with respect to difficult to machine materials Considering the applications of different sources of hybridization including mechanical thermal and chemical interactions or their combinations this book will be of interest to a range of researchers and practicing engineers within the field of manufacturing

*Multi-Criteria Decision-Making and Optimum Design with Machine Learning* Van Thanh Tien Nguyen, Nhut T.M. Vo, Van Chinh Truong, Van-Thuc Nguyen, 2024-12-11 As multicriteria decision making MCDM continues to grow and evolve machine learning ML techniques have become increasingly important in finding efficient and effective solutions to complex problems This book is intended to guide researchers practitioners and students interested in the intersection of ML and MCDM for optimal design Multi Criteria Decision Making and Optimum Design with Machine Learning A Practical Guide is a comprehensive resource that bridges the gap between ML and MCDM It offers a practical approach by demonstrating the application of ML and MCDM algorithms to real world problems Through case studies and examples it showcases the effectiveness of these techniques in optimal design The book also provides a comparative analysis of conventional MCDM algorithms and machine learning techniques enabling readers to make informed decisions about their use in different scenarios It also delves into emerging trends providing insights into future directions and potential opportunities The book covers a wide range of topics including the definition of optimal design MCDM algorithms supervised and unsupervised ML techniques deep learning techniques and more making it a valuable resource for professionals and researchers in various fields Multi Criteria Decision Making and Optimum Design with Machine Learning A Practical Guide is designed for professionals researchers and practitioners in engineering computer science sustainability and related fields It is also a valuable resource for students and academics who wish to expand their knowledge of machine learning applications in multicriteria decision making By offering a blend of theoretical insights and practical examples this guide aims to inspire further research and application of machine learning in multidimensional decision making environments

Special Issue of the Manufacturing Engineering Society 2019 (SIMES-2019) Eva M. Rubio, Ana M. Camacho, 2020-07-03 This book derives from the Special Issue of the Manufacturing Engineering Society 2019 SIMES 2019 that has been launched as a joint issue of the journals Materials and Applied Sciences The 29 contributions published in this Special Issue of Materials present cutting edge advances in the field of manufacturing engineering focusing on additive manufacturing and 3D printing advances and innovations in manufacturing processes sustainable and green manufacturing manufacturing of new materials metrology and quality in manufacturing industry 4 0 design modeling and simulation in manufacturing engineering and manufacturing engineering and society Among them the topic Additive Manufacturing and 3D Printing has attracted a large number of contributions in this journal due to its widespread popularity and potential

**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.

*Characterizations of Some Composite Materials* Hosam El-Din M. Saleh, Martin Koller, 2019-01-16 Composite materials are materials made from two or more constituents with significantly different physical or chemical properties when combined. A new material with characteristics different from the individual components is produced while the individual components remain separate and distinct within the finished structure. The new composite material often displays many beneficial characteristics. In many cases, composites are stronger, of lower density or less costly in comparison to established materials. Based on the classification of composites we are already familiar with the fact that there exists a myriad of different types of these materials. It is a common saying that different types of composites differ in their performance. Yet composites also have some characteristics in common. The proper material choice for an envisaged application is of outstanding importance and key in the development of a new product. Selecting the most suitable material determines the performance and characterization of the final product whether it will meet the designated function and performance requirements. The present book *Characterizations of some composite materials* contains eight selected chapters starting with a general introductory chapter on composite materials and covers different aspects in characterizing some composite materials. In this context the present book is considered an appropriate way to communicate the advances in characterization of some composite materials to the scientific community. Chemists, scientists and researchers from related areas and undergraduates involved in materials issues and interested in approaches to improve the quality of life as well as people from industry could find this book to be an inspiring and effective guide.

*Handbook of Materials Selection* Myer Kutz, 2002-07-22 An innovative resource for materials properties, their evaluation and industrial applications. The *Handbook of Materials Selection* provides information and insight that can be employed in any discipline or industry to exploit the full range of materials in use today: metals, plastics, ceramics and composites. This comprehensive organization of the materials selection process includes analytical approaches to

materials selection and extensive information about materials available in the marketplace sources of properties data procurement and data management properties testing procedures and equipment analysis of failure modes manufacturing processes and assembly techniques and applications Throughout the handbook an international roster of contributors with a broad range of experience conveys practical knowledge about materials and illustrates in detail how they are used in a wide variety of industries With more than 100 photographs of equipment and applications as well as hundreds of graphs charts and tables the Handbook of Materials Selection is a valuable reference for practicing engineers and designers procurement and data managers as well as teachers and students      Machining of Composite Materials II T. S. Srivatsan, C. T. Lane, D. M. Bowden, 1994

This volume is a collection of papers presented at the symposium Machining of Composite Materials II during ASM Materials Week 93 held 17-21 October in Pittsburgh PA This symposium served as a forum for discussing a variety of machining methods being developed for use with advanced composite materials A total of 20 papers covering a wide range of materials and machining techniques were presented in three sessions addressing metal matrix composites polymer and ceramic matrix composites and machining technology These papers present the latest information available on the machining processes critical to producing useful products from advanced composite materials      *Modern Design Technologies and Experiment for Advanced Manufacture and Industry* Chien Hung Liu, 2015-05-28 Selected paper from the 3rd International Conference on Engineering and Technology Innovation held in Kenting Pingtung Taiwan R O C October 31 November 4 2014

Modern Hybrid Machining and Super Finishing Processes Ankit Sharma, Amrinder Singh Uppal, Bhargav Prajwal Pathri, Atul Babbar, Chander Prakash, 2024-06-06 This book captures the recent breakthroughs in subtractive manufacturing and difficult to machine material based modern machining techniques It illustrates various combinations of hybrid machining and super finishing and outlines the critical area profile accuracy high precision machining high tolerance surface quality chipping and cracking for converting into new applications Modern Hybrid Machining and Super Finishing Processes Technology and Applications provides scientific and technological insights on subtractive manufacturing routes It covers a wide range of micromachining parts electronic components metrological devices and biomedical instruments on materials such as titanium stainless steel high strength temperature resistant alloys fiber reinforced composites and ceramics refractories and other difficult to machine alloys The book emphasizes machined surface accuracy and quality of surface productivity and automatization It also covers creating complex intricate and complicated shapes for difficult to machine materials The book goes on to offer an investigation on electrochemical discharge machining abrasive based nano finishing and rotary ultrasonic machining based parametric combination as well as discuss the latest trends in hybrid machining combined processes This book is a firsthand reference for commercial organizations mimicking modern hybrid machining processes by targeting difficult to machine materials based applications By capturing the current trends of today's manufacturing practices this book becomes a one stop resource for scholars manufacturing professionals engineers and

academic researchers     *International Aerospace Abstracts* ,1997     Metals Handbook: Machining ,1978     **Technical**  
**Digest** ,1994     *Metals Abstracts* ,1998     **Welding Handbook: Welding processes** American Welding Society,1987  
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The book delves into Abrasive Machining Of Advanced Aerospace Alloys And Composites. Abrasive Machining Of Advanced Aerospace Alloys And Composites is a vital topic that must be grasped by everyone, from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Abrasive Machining Of Advanced Aerospace Alloys And Composites, encompassing both the fundamentals and more intricate discussions.

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