Nondestructive Evaluation Of Adhesive Bonds Using 20 Mhz And 25 Khz Ultrasonic Frequencies On Metal And Polymer Assemblies

Focusing on visual and optical inspection, ultrasonics, acoustic emission, dynamic techniques, X-ray radiography, material characterization, industrial applications and qualification programmes, this book is intended for engineers and researchers, as well as teachers and graduate students.

This book is open access under a CC BY 4.0 license. It presents the results of the ComBoNDT European project, which aimed at the development of more secure, time- and cost-saving extended non-destructive inspection tools for carbon fiber reinforced plastics, adhered surfaces and bonded joints. The book reports the optimal use of composite materials to allow weight savings, reduction in fuel consumptions, savings during production and higher cost efficiency for ground operations.

In this report we examine the applicability of shearography techniques for nondestructive inspection and evaluation in two unique application areas. In the first application, shearography is used to evaluate the quality of adhesive bonds holding lead tiles to the BAT gamma ray mask for the NASA Swift program. By exciting the mask with a vibration, the more poorly bonded tiles can be distinguished by their greater displacement response, which is readily identifiable in the shearography image. A quantitative analysis is presented that compares the shearography results with a destructive pull test measuring the force at bond failure. Generally speaking, the results show good agreement. Further investigation would be useful to optimize certain test parameters such as vibration frequency and amplitude. The second application is to evaluate the bonding between the skin and core of a honeycomb structure with a specular (mirror-like) surface. In standard shearography techniques, the object under test must have a diffuse surface to generate the speckle patterns in laser light, which are then sheared. A novel configuration using the specular surface as a mirror to image speckles from a diffuser is presented, opening up the use of shearography to a new class of objects that could not have been examined with the traditional approach. This new technique readily identifies large scale bond failures in the panel, demonstrating the validity of this approach. For the particular panel examined here, some scaling issues should be examined further to resolve the measurement scale down to the very small size of the core cells. In addition, further development should be undertaken to determine the general applicability of the new approach and to establish a firm quantitative foundation. Lysak, Daniel B. Goddard Space Flight Center NASA/CR-2003-212231

Proceedings of the ... Symposium on Nondestructive Evaluation

The Nondestructive Testing of Strength of Adhesive Bonds

Non-destructive Testing and Quality Assurance Concepts

Electromagnetic Non-Destructive Evaluation (XXIII)

Evaluation of Composite Adhesive Bonds Using Digital Image Correlation

This state-of-the-art report describes the bonding process, the destructive methods used to measure bond strength, and the various NDE methods that have been evaluated for determining the quality of a bond. These NDE methods include sonics, ultrasonics, acoustic emission, nuclear magnetic resonance, x radiography, optical holography, and thermography. Each of these methods has shown some limited success in detecting debond conditions. At the present time, however, it appears that only the sonic, ultrasonic, and nuclear magnetic resonance methods have the potential capability to differentiate qualitative between a good bond and a debond and thus provide a correlation to bond strength. Nondestructive testing; Adhesive bonds; Adhesive bond testing; Adhesive bond strength; Sonic testing; Ultrasonic testing.

For several years, I have been responsible for organizing and teaching in the fall a short course on "Fundamentals of Adhesion: Theory, Practice, and Applications" at the State University of New York at New Paltz. Every spring I would try to assemble the most pertinent subjects and line up several capable lec course. However, there has always been one thing missing-an authoritative book that covers most aspects of adhesion and adhesive bonding. Such a book would be used by the participants as a main reference throughout the course and kept as a sourcebook after the course had been completed. On the oth not be one of those "All you want to know about" volumes, simply because adhesion is an interdisciplinary and ever-growing field. For the same reason, it would be very difficult for a single individual, especially me, to undertake the task of writing such a book. Thus, I relied on the principle that one leaves the tr jobs to experts, and I finally succeeded in asking several leading scientists in the field of adhesion to write separate chapters for this collection. Some chapters emphasize theoretical concepts and others experimental techniques. In the humble beginning, we planned to include only twelve chapters. However, w such a plan would leave too much ground uncovered, and we resolved to increase the coverage. After the book had evolved into thirty chapters, we started to feel that perhaps our mission had been accomplished.

This report describes the results of a successful effort to demonstrate the feasibility of using leaky Lamb waves to detect and delineate flaws in the bond surface of metal/rubber laminates, even when adherends remain in intimate contact. It is shown that the leaky Lamb wave method can detect and image a po when conventional pulse-echo method failed even to detect the flaw. A new technique was implemented for preparing partially bonded surfaces by varying the percentage of adhesive coverage, and results are provided that illustrate the sensitivity of the leaky Lamb wave method in detecting different surfaces technique. An analytical model of the leaky Lamb wave phenomenon in homogenous, isotropic metal/rubber laminates is described. Numerical results for a metal/rubber laminate immersed in water are included.

Volume 11A

Adhesive Bonding of Aircraft Composite Structures

Shearography for Non-Destructive Evaluation with Applications to Bat Mask Tile Adhesive Bonding and Specular Surface Honeycomb Panels

Ultrasonic Nondestructive Evaluation of Adhesive Bond Degradation

Development of Nondestructive Tests for the Evaluation of Bonded Materials

This volume presents original research in the broad areas of technical design and nondestructive testing procedures. It provides critical information for managers, materials scientists, quality control specialists and engineers who must stay abreast of rapidly advancing methods for the detection and measurement of the performance capabilities for parts, equipment and structures. Papers of special interest to the aircraft, nuclear and automotive industries include adhesive bonding of lap joints, nuclear radiography, nuclear tomography, use of hte leaky lamb wave technique to determine the dynamic elastic moduli of a fiber-reinforced composite, and a comparison of the resonant technique with the impact-echo technique.

The intention of this book is that it should contain everything an engineer needs to know to be able to design and produce adhesively bonded joints which are required to carry significant loads. The advan tages and disadvantages of bonding are given, together with a sufficient understanding of the necessary mechanics and chemistry to enable the designer to make a sound engineering judgement in any particular case. The stresses in joints are discussed extensively so that the engineer can get sufficient philosophy or feel for them, or can delve more deeply into the mathematics to obtain quantitative solutions even with elasto plastic behaviour. A critical description is given of standard methods of testing adhesives, both destructively and non-destructively. The essen tial chemistry of adhesives and the importance of surface preparation are described and guidance is given for adhesive selection by me ans of check lists. For many applications, there will not be a unique adhesive which alone is suitable, and factors such as cost, convenience, produc tion considerations or familiarity may be decisive. A list of applications is given as examples. The authors wish to increase the confidence of engineers using adhesive bonding in load-bearing applications by the information and experience presented. With increasing experience of adhesives en gineering, design will become more elegant as weH as more fitted to its products.

Electromagnetic Non-destructive Evaluation (ENDE) is an invaluable, non-invasive diagnostic tool for the inspection, testing, evaluation and characterization of materials and structures. It has now become indispensible in a number of diverse fields ranging from biomedics to many branches of industry and engineering. This book presents the proceedings of the 24th International Workshop on Electromagnetic Nondestructive Evaluation, held in Chengdu, China from 11 - 14 September 2019. The 38 peer-reviewed and extended contributions included here were selected from 45 original submissions, and are divided into 7 sections: eddy current testing and evaluation; advanced sensors; analytical and numerical modeling; material characterization; inverse problem and signal processing; artificial intelligence in ENDE; and industrial applications of ENDE. The papers cover recent studies concerning the progress and application of electromagnetic (EM) fields in the non-destructive examination of materials and structures, and topics covered include evaluations at a micro-structural level, such as correlating the magnetic properties of a material with its grain structure, and a macroscopic level, such as techniques and applications for EM NDT&E. Recent developments and emerging materials such as advanced EM sensors, multi-physics NDT&E, intelligent data management and maintaining the integrity of structures are also explored. The book provides a current overview of developments in ENDE, and will be of interest to all those working in the field.

Nondestructive Evaluation of Adhesive Bond Quality: State of the Art Review

Second volume

Non-Destructive Evaluation (NDE) of Polymer Matrix Composites

Special Issue on Nondestructive Testing of Adhesive Bonds

Adhesion Science and Engineering

A technique which uses the reflected waveform data to obtain the fundamental ultrasonic parameters (transit time, reflection coefficient and attenuation coefficient) of an adhesive bond has also been presented.

Examines the initiation and growth of fatigue cracks and the fracture toughness of advanced materials such as silicon nitride, special alloys and steels, thermoplastics, and graphite-epoxy composites; and explains several non-destructive techniques to evaluate such materials for manufacturing defect

Ultrasonic testing remains the most common Non-Destructive Evaluation (NDE) technique for inspecting adhesive joints at the bond line as it can be targeted at small volume elements of interest. Whilst it can detect finite thickness disbonds, there is still no known NDE technique to detect kissing bonds (KB) and therefore assess the integrity of the bond. The literature describes the potential of non linear ultrasonic techniques, but previous work has failed to fully quantify nonlinearities generated by the experimental system. In this thesis, a new prediction tool that provides realistic simulations of nonlinear ultrasonic wave propagation is introduced to assess the detectability of KB in multi-layered structures. A series of experiments that quantify nonlinearities generated by the different sources are described, and a finite-element (FE) model in which the experimental data is incorporated is developed. This new prediction tool is expected to enable NDE engineers to know whether KB are at all detectable in a given adhesive joint, and if so, what experimental set-up, driving frequency and post-processing method to use in order to optimise KB detection capability.

A Quantitative Measure

NDE (Nondestructive Evaluation) of Adhesive Bonds. Phase 1

Nondestructive Testing of Adhesive Bonds

Surfaces, Chemistry and Applications

Nondestructive Evaluation (NDE) of Adhesive Bonds

Advanced composite materials are widely used for many structural applications in the aerospace/aircraft industries today. Joining of composite structures using adhesive bonding offers several advantages over traditional fastening methods. However, this technique is not yet employed for fastening the primary structures of aircrafts or space vehicles. There are several reasons for this: There are not any reliable non-destructive evaluation (NDE) methods that can quantify the strength of the bonds, and there are no certifications of quality assurance for inspecting the bond quality. Therefore, there is a significant need for an effective, reliable, easy to use NDE method for the analysis of composite adhesive joints. This research aimed to investigate an adhesively bonded composite-aluminum joints of variable bond strength using digital image correlation (DIC). There are many future possibilities in continuing this research work. As the application of composite materials and adhesive bond are increasing rapidly, the reliability of the composite structures using adhesive bond should quantified. Hence a lot of similar research using various adhesive bonds and materials can be conducted for characterizing the behavior of adhesive bond. The results obtained from this research will set the foundation for the development of ultrasonic DIC as a nondestructive approach for the evaluation of adhesive bond line.

Commercial and military use of adhesive fastening is wisespread and continues to grow rapidly. This growth is indicative of the significant advantages of adhesive bonding over other fastening methods, in that it proceeds in the face of many disadvantages. Current adhesive systems are designed to be forgiving of some latitude in processing, but substandard bonds do occur, and these cannot be tolerated in critical applications. The extent of controls and tests necessary to assure highly reliable adhesive bonds does not appear to be generally appreciated in that many presently available procedures are often ignored. Nondestructive testing can contribute to the production of more reliable adhesive bonds by (1) providing rapid, economical tests for in-process measurement and control to supplement and replace some of the lengthy destructive procedures now required, and (2) providing a non-contaminating means to evaluate the suitability of surfaces for bonding. Based on bonding theory, it appears that this latter may best be done through development of a rapid means to determine the work function of surfaces compatible with production requirements. (Author).

The Mechanics of Adhesion shows that adhesion science and technology is inherently an interdisciplinary field, requiring fundamental understanding of mechanics, surfaces, and materials. This volume comprises 19 chapters. Starting with a background and introduction to stress transfer principles; fracture mechanics and singularities; and an energy approach to debonding, the volume continues with analysis of structural lap and butt joint configurations. It then continues with discussions of test methods for strength and constitutive properties; fracture; peel; coatings, the case of adhesion to a single substrate; elastomeric adhesives such as sealants. The role of mechanics in determining the locus of failure in bonded joints is discussed, followed by a chapter on rheology relevant to adhesives and sealants. Pressure sensitive adhesive performance; the principles of tack and tack measurements; and contact mechanics relevant to wetting and surface energy measurements are then covered. The volume concludes with sections on fibermatrix bonding and reinforcement; durability considerations for adhesive bonds; ultrasonic non-destructive evaluation of adhesive bonds; and design of adhesive bonds from a strength perspective. This book will be of interest to practitioners in the fields of engineering and to those with an interest in adhesion science.

A State-of-the-art Report

Structural Adhesive Joints in Engineering

International Advances in Nondestructive Testing

Review of Progress in Quantitative Nondestructive Evaluation

Development of Ultrasonic Techniques for Nondestructive Evaluation of Adhesive Bonds

A reference that offers comprehensive discussions on every important aspect of aluminum bonding for each level of manufacturing from mill finished to deoxidized, conversion coated, anodized, and painted surfaces and provides an extensive, up-to-date review of adhesion science, covering all significa

The increased use of polymer matrix composites in structural applications has led to the growing need for a very high level of quality control and testing of products to ensure and monitor performance over time. Non-destructive evaluation (NDE) of polymer matrix composites explores a range of NDE techniques and the use of these techniques in a variety of application areas. Part one provides an overview of a range of NDE and NDT techniques including eddy current testing, shearography, ultrasonics, acoustic emission, and dielectrics. Part two highlights the use of NDE techniques for adhesively bonded applications. Part three focuses on NDE techniques for aerospace applications including the evaluation of aerospace composites for impact damage and flaw characterisation. Finally, the use of traditional and emerging NDE techniques in civil and marine applications is explored in part four. With its distinguished editor and international team of expert contributors, Non-destructive evaluation (NDE) of polymer matrix composites is a technical resource for researchers and engineers using polymer matrix composites, professionals requiring an understanding of non-destructive evaluation techniques, and academics interested in this field. Explores a range of NDE and NDT techniques and considers future trends Examines in detail NDE techniques for adhesively bonded applications Discusses NDE techniques in aerospace applications including detecting impact damage, ultrasonic techniques and structural health monitoring

Nondestructive Evaluation of Adhesive BondsNondestructive Evaluation of Adhesive Bonds Using 20 MHz and 25 kHz Ultrasonic Frequencies on Metal and Polymer AssembliesAuthor House

An Ultrasonic Technique for Non-destructive Evaluation of Metal-to -metal Adhesive Bonds

Electrochemical Sensors for Nondestructive Evaluation of Adhesive Bonds

Numerical Simulation of Ultrasonic Nondestructive Evaluation of Adhesive Bond Integrity

Ultrasound NDE of Adhesive Bond Integrity

Cyclic Deformation, Fracture, and Nondestructive Evaluation of Advanced Materials

Demands for improvements in aerospace and automotive energy-efficiency, performance, corrosion resistance, body stiffness and style have increased the use of adhesive bonds to help meet those demands, by providing joining technology that accommodates a wider variety of materials and design options. However, the history of adhesive bond performance clearly indicates the need for a robust method of assuring the existence of the required consistent level of adhesive bond integrity in every bonded region. The Quality Assurance of Adhesive Bonds by Ultrasonic Nondestructive Testing technology put forth in this book meets that need by describing two new, complementary ultrasonic techniques for the evaluation of these bonds, and thus provide improvements over previous methods. The development of a 20 MHz pulse-echo method for nondestructive evaluation of adhesive bonds will accomplish the assessment of bond joints with adhesive as thin as 0.1 mm. This new method advances the state of the art by providing a high-resolution, phase-sensitive procedure that identifies the bond state at each interface of the adhesive with the substrate(s), by the acquisition and analysis of acoustic echoes reflected from interfaces between layers with large acoustic impedance mismatch. Because interface echo amplitudes are marginal when the acoustic impedance of the substrate is close to that of the adhesive, a 25 kHz Lamb wave technique was developed to be employed in such cases, albeit with reduced resolution. Modeling the ultrasonic echoes and Lamb-wave signals was accomplished using mathematical expressions developed from the physics of acoustic transmission, attenuation and reflection in layered media. The models were validated by experimental results from a variety of bond joint materials, geometries and conditions, thereby confirming the validity of the methodology used for extracting interpretations from the phase-sensitive indications, as well as identifying the range and limits of applications. Results from the application of both methodologies to laboratory specimens and to samples from production operations are reported herein, and show that bond-joint integrity can be evaluated effectively over the range of materials and geometries addressed.

In the current volume, consisting of Parts A and B, edited vers ions of most of the papers presented at the annual Review of Progress in Quantitative Nondestructive Evaluation held at Bowdoin College, Brunswick, Maine on July 28-August 2, 1991 have been collected. The Review was organized by the Center for NDE at Iowa State University and the Ames Laboratory of the USDOE in cooperation with a number of organizations including the Air Force Materials Directorate, Wright Laboratory, Wright Patterson Air Force Base, the American Society for Nondestructive Testing, the Center for NDE at Johns Hopkins University, Department of Energy, Federal Aviation Administration, National Institute of Standards and Technology, National Science Foundation IndustryjUniversity Cooperative Research Centers, and the Office of Naval Research. The 1991 Review of Progress in QNDE was attended by approximately 450 participants from the US and many foreign countries who presented over 360 papers. Divided into 36 sessions, with as many as four sessions running concurrently, the meeting covered all phases of NDE development from basic research to engineering applications and all methods of inspection science from acoustics to x-rays. Over the past ten years, the participants of the Review have seen it grow into one of the largest and most significant gatherings of NDE researchers and engineers anywhere in the world. By sharing their work at this conference, they deserve much credit for its success.

Materials Characterization Using Nondestructive Evaluation (NDE) Methods discusses NDT methods and how they are highly desirable for both long-term monitoring and short-term assessment of materials, providing crucial early warning that the fatigue life of a material has elapsed, thus helping to prevent service failures. Materials Characterization Using Nondestructive Evaluation (NDE) Methods gives an overview of established and new NDT techniques for the characterization of materials, with a focus on materials used in the automotive, aerospace, power plants, and infrastructure construction industries. Each chapter focuses on a different NDT technique and indicates the potential of the method by selected examples of applications. Methods covered include scanning and transmission electron microscopy, X-ray microtomography and diffraction, ultrasonic, electromagnetic, microwave, and hybrid techniques. The authors review both the determination of microstructure properties, including phase content and grain size, and the determination of mechanical properties, such as hardness, toughness, yield strength, texture, and residual stress. Gives an overview of established and new NDT techniques, including scanning and transmission electron microscopy, X-ray microtomography and diffraction, ultrasonic, electromagnetic, microwave, and hybrid techniques Reviews the determination of microstructural and mechanical properties Focuses on materials used in the automotive, aerospace, power plants, and infrastructure construction industries Serves as a highly desirable resource for both long-term monitoring and short-term assessment of materials

Use of Nonlinear Ultrasonics for Non-destructive Evaluation of Adhesive Joints

Controle Non Destructif de Joints Colles Par Thermographie Infrarouge

Materials Characterization Using Nondestructive Evaluation (NDE) Methods

Adhesive Bonding

An in-situ corrosion sensor based on electrochemical impedance spectroscopy (EIS) has been used to detect moisture ingress into aluminum-aluminum and aluminum-composite adhesive bonds. Both wedge tests and tensile button tests (aluminum-aluminum bonds only) were performed. Upon moisture absorption, the impedance spectra change shape with the low-frequency region becoming resistive. The low-frequency impedance decreases by several orders of magnitude, depending on the adhesive and the experimental conditions. For bonds with stable interfaces, such as phosphoric acid anodized (PAA) aluminum, the absorbed moisture causes an initial weakening of the adhesive resulting in reduced strength or small crack propagation. A substantial incubation time prior to substrate hydration and bond degradation allows warning of potential joint deterioration and enables condition-based maintenance. For bonds with smooth interfaces with little or no physical bonding (mechanical interlocking), crack propagation can proceed inter-facially with minimal moisture absorption. A comparison of the incubation times for Forest Products Laboratory (FPL) surfaces both bonded to epoxy adhesives and freely exposed to water or humidity at different temperatures shows that hydration occurs with the same activation energy, independent of whether or not the surface is covered with adhesive. However, the pre-exponential factor in the rate constant is dependent on the concentration of free moisture at the interface' so that the hydration rate varies by several orders of magnitude. The results of this study demonstrate that the electrochemical sensor technology can detect the ingress of moisture into an adhesive bond and should be further developed to provide a means to warn of potential degradation of adhesive joints and enable condition-based maintenance.

After decades of work to develop bonded primary structures for DoD and NASA applications, there has been little use of adhesive-bonded joints in critical structures. A primary barrier to application of adhesive-bonded structures is a perception of poor reliability. To meet current and future requirements, a review and evaluation of the current state-of-the-art of the NDE knowledge base and hardware for assessing the quality, reliability and integrity of adhesive bonds has been performed by NTIAC with the results documented in this report.

Nondestructive Evaluation of Adhesive Bonds
Experiment
Theory
Nondestructive Evaluation of the Adhesive Bond Strength in Laminated Safety Glass
Nondestructive Evaluation of the Adhesive Bond Strength of Laminated Wood Finger Joints and Laminated Safety Glass