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Book Reviews

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Recent Advances in Structural Joints and Repair for Composite Materials

Edited by Liyong Tong and Costas Soutis, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2003, 254 pp., $121.00

This book is a collection of seven chapters on the analysis and design of adhesive-bonded and mechanically fastened joints with a focus on laminated composite structures. The seven chapters are written by six sets of authors. They cover the stress analysis and design of bonded and bolted joints, strength analysis of bonded repairs, and design and analysis of bonded and bolted joints for fibrous composite structures.

The first chapter, Stress Analysis and Failure Assessment of Lap Joints, by C. H. Wang and L. R. F. Rose, is concerned with the stress analysis of bonded joints. Closed-form solutions for maximum shear and normal (peel) stresses in terms of the thickness of adherend and adhesive layer are presented without any derivation. However, more than 40 references are listed at the end of the chapter. Joint failure criteria are discussed with particular emphasis on fracture-mechanics-based theories. End effects, stress concentration in adherends, and the effects of triaxial stress state on plastic yielding are briefly covered in this chapter.

The second chapter, Strength Determination of Adhesive Bonded Joints, by L. Tong, J. K. Spelt, and G. Fernlund, has a scope very similar to that of the first one, but the approach is slightly different in that more detailed treatment of energy release rate in joints is given. The R-curve effect in adhesive layers and the strong dependence of the critical energy release rate on mode mixity in various adhesive systems are worth noting. This chapter presents experimental results and material properties for several systems that the reader may find useful. Composite-to-composite bonding is discussed in detail, with several sets of numerical results comparing various failure criteria. Strength prediction of bonded joints under cyclic loading and formulas for creep strength are included.

F. L. Matthews and P. P. Camanho authored the third chapter, Stresses in Mechanically Fastened Joints, which begins with a review of experimental results concerning the failure of bolted joints in composite laminates. Different failure modes are described, and the factors that influence such failures, e.g., influence of stacking sequence, fastener type, etc., are discussed. Semianalytical and numerical methods for determining the stresses in bolted joints in composite laminates, including two- and three-dimensional methods, are reviewed, and the results are used in the discussion of strength prediction of bolted joints. Some methods described include the two-parameter method, e.g., Whitney–Nuismer criterion, combined methods in which the concept of characteristic length is combined with a failure theory, the fracture mechanics approach, and progressive damage models. Eighty-three references are cited in this chapter.

The progressive damage model is considered in detail in the fourth chapter, Strength Determination of Mechanical Fastened Joints, by F.-K. Chang and X. L. Qing. The progressive damage model is composed of three major parts: constitutive modeling, damage estimator, and stress analysis. Step-by-step procedures for using the aforementioned concepts for predicting the strength of a composite bolted joint are described in great detail. Verification of the methods is performed by comparing results of the damage model with data obtained from experiments. Methods to take into account the effects of clamping, combined bearing and axial bypass loads, and transverse bypass loads on the joint strength are discussed. This chapter presents many practical analytical/numerical methods for predicting the strength of mechanically fastened joints in laminated composites.

The fifth chapter, Strength Analysis of Adhesively Bonded Repairs, by C. Soutis and F. Z. Hu, is mainly a summary of previous papers published by the authors on this topic. They describe different types of patch repairs for damaged composite structures, design procedures, and strength prediction of repaired laminate. Finite element models for repaired laminates are described, and the theoretical basis for the models is presented. Similar procedures for scarf-patch repairs are also given.

The last two chapters, written by L. J. Hart-Smith, are concerned with adhesively bonded joints and mechanically fastened joints, respectively, for fibrous composite structures. Obviously there is a lot of overlap in scope between these two chapters and preceding chapters. However, the author draws upon his personal research experience over many years in the field of composite materials and structures. Consequently, the author is able to provide a very thorough and vivid description of the behavior of various adhesively bonded joint configurations. Leaving the mathematical details to the references, the author is able to explain the various failure modes of bonded joints and the corresponding criterion to be used in predicting failure. Joint efficiency charts are provided for single-lap composite joints for both ductile and brittle adhesive systems. A highlight of the chapter is the section entitled Rules of Thumb for Designing Structurally

Efficient Joints, which lists all of the factors that a designer must take into consideration in designing a bonded joint for laminated composite structures.

The last chapter, which deals with the analysis and design of bolted/riveted joints for composite structures, has a flavor similar to that of the preceding chapter on bonded joints. The author presents the philosophy behind the design and analysis of bolted joints from a general point of view such that it can be used for many different composite materials systems. In the words of the author, "one purpose of such a presentation is to define the minimum test program that can be used to adequately characterize bolted joints in any composite material." The details of the stress field in a composite bolted joint and their effects on the strength of the joint are described methodically. Effects of fiber pattern on the failure modes and consequently on the strength are described. Correlation between tests and theory are provided, and semi-empirical formulas for the stress concentration factor at failure are derived. The chapter ends with a section on Rules of Thumb for Designing Structurally Efficient (bolted/riveted) Joints.

One of the drawbacks of this book is that the chapters are written by different authors, and another is that the first five chapters read more like a review paper than a comprehensive treatise on the respective topics. The reader is expected to be very familiar with the topic of joints in composite structures, in which case the book does not fully serve its intended purpose. There is no continuity between the chapters, which can be an advantage in the sense that a chapter can be read without reading the preceding ones. Readers may find the references listed at the end of each chapter useful. This is particularly true for young researchers who would like to begin a research program in composite joints and repair. As already mentioned, Chapters 6 and 7 are written in a comprehensive manner and will be very useful for practicing engineers working in the field of design and analysis of composite joints and repairs. The comments made here should not be taken as a criticism of the editors or the authors but rather as a reflection on the nature of a book about an emerging and evolving field of composite materials research. Such books lay the foundation for future authors, who may plan to write a more comprehensive textbook with a unified treatment on this topic.

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Ignition Handbook

Vytenis Babrauskas, Fire Science Publishers, Issaquah, WA, 2003, 1116 pp. plus CD database, $198.00 (book) and $60.00 (CD database)

Ignition of materials is a complicated subject whether ignition is deliberate (i.e., internal combustion engine) or not (i.e., unwanted fires). The author succeeds in combining both types of ignition circumstances into a well-documented and useful compilation for the novice as well as the expert. Even though the major focus of the handbook is on the prevention of unwanted fires, a significant amount of valuable information is available for the student or research scientist who has an interest in ignition characteristics. The overall organization and layout of the handbook represents a well-thought-out strategy for facilitating a better understanding of the topic.

Chapter 2 provides an excellent glossary of terms and acronyms that are frequently used in the field, which is useful for newcomers to the field. Chapter 3 contains a brief summary of combustion fundamentals and chemical kinetics, both of which are important for understanding ignition in various systems. Chapters 4–7 address ignition mechanisms and characteristics of conventional gaseous mixtures, dust clouds, liquids, and common solids. These chapters discuss the basic theory associated with the ignition system as well as the mechanisms that influence the ignition characteristics such as pressure, temperature, oxygen concentration, shock or compression sensitivity, molecular structure, diluents, and safety considerations. Chapter 8 is an overview of ignition of metal dust clouds and single particles. Both empirical and theoretical aspects are described in detail, in addition to the effects of moisture, available oxygen, and flow velocity on ignition. The detailed discussion on common ignition sources given in Chapter 11 should prove useful to the fire prevention community. Each possible type of ignition mechanism is presented and well discussed, covering methodology, techniques, and general principles. Chapter 14 is an exceptional collection of information on specific materials and devices and can be helpful in research investigations beyond the topic of ignition alone. Specific details include types of metal fuels, reactive gases, polymers, oxidizing compounds, oils, safety, techniques, flame and ignition probabilities—to name just a few.

Overall, this book, with its experimental and theoretical contributions, successfully addresses the complex phenomena of ignition and its characteristics. Various modes and mechanisms of ignition (specifically focusing on preventative methods) are presented and carefully explained using past and present work of the foremost authorities in each topic. From a nontechnical standpoint, it contains a plethora of interesting and informative color photographs illustrating common unwanted encounters with ignition, heat, and combustion.

In summary, I highly recommend that those studying any aspect of ignition, especially in the area of fire prevention, should include this ignition handbook in their personal technical library.

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