DEFECT COUPLING

Predicting the Strength and Life of Fibrous Composite Laminates

Ken Reifsnider, Rassel Raihan and Vamsee Vadlamudi

University of Texas Arlington

A B S T R A C T

After more than 30 years of careful experimental investigation and exhaustive development of discrete damage analysis methods including integrated computational mechanics methods, our community knows a great deal about how discrete defects such as matrix cracks and defect growth (e.g. delamination) can be predicted. But for many practical situations controlled by laminated multiaxial composite structures, the loss of performance and "sudden death" end of life is controlled by defect coupling which becomes a precursor to fracture plane development.

Until recently, analysis methods to address such complex interaction and coupling of multiple defects and experimental methods of following the details of such interaction sequences as a foundation for understanding and model validation were not available. We believe that this barrier has been largely removed by recent work. The present discussion outlines the methods and lessons learned and sets the foundation for Predicting the strength and Life of Fibrous Composite Laminates from analysis and simulation, or from material state data recorded during service.

Kenneth Reifsnider

Founder, Institute for Predictive Performance Methodologies

Mechanical and Aerospace Engineering

University of Texas Arlington

B I O

Dr. K.L. (Ken) Reifsnider is Presidential Distinguished Professor and Director of the Institute for Predictive Performance Methodologies (IPPM) at the University of Texas Arlington Research Institute, and Professor of Mechanical and Aerospace Engineering at that University. The IPPM is a faculty cluster for the development of predictive methodologies in the areas of structural reliability, additive manufacturing, multi-scale multi-functional materials and bio-sensors. Prior to this appointment, Dr. Reifsnider was Director of the SmartState Center for Solid Oxide Fuel Cells at the University of South Carolina, Director of the Center for Heterogeneous Functional Materials (the HeteroFoaM Center), and University Professor of Solid Oxide Fuel Cell Science and Technology at that University (2007 – 2015); he currently holds Emeritus status in those positions. From 2002 to 2007, Prof. Reifsnider was Pratt & Whitney Professor of Design and Reliability in the Mechanical Engineering Department at the University of Connecticut and Director of the Connecticut Global Fuel Cell Center. In 2004 he became the first full time faculty member at the University of Connecticut ever to be elected to the National Academy of Engineering. Dr. Reifsnider is also Professor Emeritus of Engineering Science and Mechanics at Virginia Tech where he was named the first holder of the Alexander Giacco endowed chair in 1990, one of only four such million dollar chairs at Virginia Tech at that time. During 1995-2000 Dr. Reifsnider served as Associate Provost for Interdisciplinary Programs at Virginia Tech. He has also held teaching positions at Western Maryland College, The Johns Hopkins University, the University of California, and a visiting position at the University of Bristol, England. Dr. Reifsnider is co-founder of the Virginia Tech Center for Composite Materials and Structures, and past Director of the Virginia Institute for Material Systems (a Commonwealth Center), and past Deputy Director of the NSF Center for High Performance Polymeric Adhesives and Composites (1992-2000). From 1974 to 1992, Dr. Reifsnider served as Chairman of the Materials Engineering Science PhD program at Virginia Tech, during which time the program grew by a factor of ten, with participation by 47 faculty and 63 students in nine departments in three colleges. From 1996-2001, Dr. Reifsnider served as the Associate Provost for Interdisciplinary Programs at Virginia Tech, charged with creating and staffing that office. In the Fall of 2002, Dr. Reifsnider accepted the Pratt & Whitney Chair of Design and Reliability in the Department of Mechanical Engineering at the University of Connecticut, Storrs, with an appointment in the Global Fuel Cell Center at that University. As a scholar, Dr. Reifsnider has published over 240 articles in refereed journals, several book chapters, and (edited) 11 books. His signature book on "Damage Tolerance and Durability of Composite Material Systems" (Wiley Interscience) was published in April 2002. His appearances include numerous plenary and keynote addresses, and over 100 invited lectures in 20 foreign countries. He has served on many national committees, including the National Materials Advisory Board and panels of the National Research Council. Dr. Reifsnider has directed over 50 graduate student programs, and has directed research for over 160 projects funded by more than 50 different organizations. Dr. Reifsnider has served on the Editorial Boards of six journals, served for ten years as the North American Editor and Editor-in-Chief for the International Journal of Fatigue, and Associate Editor of the Journal of Applied Composites, and recently completed a term as Associate Editor of the International Journal of Fuel Cell Science and Technology. He currently serves on the Editorial Board of the International Journal of Multifunctional Composites. Dr. Reifsnider served two terms as a White House appointee to the U.S. Air Force National Scientific Advisory Board. He has also served on the National Materials Advisory Board and on numerous Panels of the National Academies and the National Research Council. In 2016 Dr. Reifsnider was honored by the International Conference on Computational and Experimental Engineering and Sciences with an ICCES Lifetime Achievement Medal for pioneering contributions to the mechanics and applications of composite materials. Dr. Reifsnider holds the Distinguished Research Award from the American Society for Composites, the J. Shelton Horsley Research Award from the Virginia Academy of Science, the Award of Merit from the American Society for Testing and Materials, the Russell Research Award from the University of South Carolina, and the Alumni Award for Research Excellence from Virginia Tech. He has served on the Board of Directors of ASTM and the Institute for Standards Research, and served as Chairman of the Board of Trustees of the latter company in 1989. In 2004, Dr. Reifsnider was elected to the National Academy of Engineering in recognition of "the development of strength – life relationships in composite materials;" in 2005 he was elected to the Connecticut Academy of Science and Engineering.