Multiscale and Multiphysics Study of Composite Failures

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Abstract

Multiscale and multiphysics modeling and experiments will be presented to understand and predict failure of composite materials and structures. The presentation includes recently developed unified failure criteria for brittle materials including polymer composites materials. The same failure criteria can be applied to structural components regardless of whether they have cracks, cutouts, or none of them. The criteria consist of two parts. One part is a stress-based criterion, and the other part is the stress gradient-based criterion. In order to have failure, both parts of the failure criteria must be satisfied. Failure of composites is also modelled using a multiscale approach such that the failure criteria can be applied to the fiber and matrix material level. The failure criteria use micro-stresses/strains at the fiber and matrix level. Failure modes are fiber breakage/buckling, matrix cracking, and fiber-matrix interface debonding. The multiscale modeling consists of both upscaling and downscaling processes, which use analytical solutions to make the overall multiscale approach computationally efficient. Finally, dynamic response and failure of composite structure with Fluid-Structure-Interaction (FSI) is presented, which includes both mechanical impact loading as well as underwater shock loading. Experimental design, physical testing, and numerical modeling and simulation are presented.

Biosketch

Dr. Kwon is Distinguished Professor in the Mechanical and Aerospace Engineering Department of the Naval Postgraduate School (NPS) in Monterey, California, USA. He served as Chair of the department. He received his Ph.D. degree from Rice University, and B.S. degree from Seoul National University, all in mechanical engineering. Before joining NPS, he was Assistant Professor at the University of Missouri-Rolla (presently Missouri University of Science and Technology). His research interests are multiscale, multiphysics and multidisciplinary problems in engineering and sciences with applications to composite materials/structures, fluid-structure interaction, energy harvesting, biomechanics, etc. He wrote the textbook, *Finite Element Method using MATLAB*, which was translated into Greek. He also authored books titled *Multiscale and Multiphysics Modeling: Techniques and Applications* and *Fluid Structure Interaction of Composite Structures* which was translated into Chinese. Prof. Kwon received many awards including the Cedric K. Ferguson Medal from Society of Petroleum Engineers, Menneken Faculty Awards for Outstanding Scientific Research, Excellent Research Award from American Orthopedic Society of Sports Medicines, Outstanding Instruction and Research Awards, ASME (American Society of Mechanical Engineers) Dedicated Service Award, ASME PVPD Outstanding Service Award, ASME Board of Governors Award, National Dean's List, etc. He is also the recipient of ASME S. Y. Zamrik PVP Medal. He is a Fellow of American Society of Mechanical Engineers. Dr. Kwon is the Technical Editor of *Journal of Pressure Vessel Technology* published by ASME as well as *Multiscale and Multidisciplinary Modeling, Experiments, and Design* published by Springer Nature. He served as ASME PVP Division Chair. He is also a Series Editor of *Lecture Notes in Mechanical Engineering* by Springer and *Springer Tracks in Mechanical Engineering*.

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