

Preface

This book on the “Effects of Fluids on Polymers and Polymeric Composites” written by my good friend and colleague, late Dr. Y. Jack Weitsman, is a relatively rare and comprehensive treatise on understanding the degradation of polymer composites and polymeric sandwich structures to harsh environment comprising of high level of humidity or for the case of marine structures which are completely surrounded by sea water. As was demonstrated, most polymeric composites absorb moisture, which is characterized by the weight gain data with time. From such simple measurements, profound statements can be inferred with respect to long-term behavior and stability of such composites when exposed to fluids (mostly water). This book has ten chapters arranged in a systematic fashion.

Chapter 1 provides a summary outlook on this complex topic with suggested three key references that address the static and dynamic mechanical behavior and associated degradation of composites from fluid exposure. Since the topic requires mastery of polymer science and engineering, engineering mechanics, chemical and polymer characterization, and thermodynamics of multi-phase materials, the author’s perspective is more slanted on solid mechanics aspect of these materials. Jack had consistent financial support for three decades to study this topic from the Solid Mechanics Program managed by Dr. Yapa Rajapakse at the United States Office of Naval Research (ONR). Thus, the author is uniquely qualified to address this complex topic.

Chapter 2 provides a quick summary of materials involved with composite materials associated polymeric resin, reinforced fibers, and composite systems. Much of the discussion is focused on glass, graphite, and carbon fiber reinforcements and a few select resin systems that have been used in aerospace and naval applications. Thus, the material is of practical and immediate relevance to a broad class of problems.

Chapters 3–5 address the mechanisms associated with fluid ingress and polymer molecular structure, simple ways in the laboratory to obtain phenomenological data for composites prepared using a given manufacturing process (for example using pre-preg’s cured in an autoclave oven or recently popular VARTM based approach)

using moisture weight gain studies, and interpreting the data with mathematically rigorous diffusion models, reasons for fluid ingress, and coupling of fluid and time effects on mechanical properties through fluid enhanced viscoelasticity approach.

Chapter 7 includes a very important underlying concept of reduced strength and fatigue life for composites when subjected to repeated loading if the fluid is allowed to enter matrix resin while the composite material is subjected to dynamic loading. If the fluid is incompressible water, then water enters the matrix cracks while the composite sample is being subjected to fatigue loading and can significantly reduce the number of cycles to failure under fluid confined conditions.

Chapter 8 addresses our recent work on the topic of sandwich structures which consist of thin polymeric composites sandwiched with a low density core material such as balsa wood or PVC foam. Such materials are of significant recent interest for building light weight and durable ship structures and fluid (sea water in our studies) can have deleterious effect on interface fracture behavior (quantified using pertinent mode critical energy release rate) and shape distortions resulting from one sided exposure to sea water induced expansion. Shear lag theory has been found to adequately describe the shape distortions observed under controlled conditions for carbon-vinyl ester composite facings and PVC foam core based sandwich.

Chapters 9 and 10 deal with anomaly associated with fluid uptake in polymers and composites based on micro-structure characterization work and major conclusions presented in the book.

In my personal opinion, this book is a must read for engineers and scientists associated with using and developing polymeric composites and novel sandwich structural materials. In addition, it will be an excellent introductory graduate level book for an inter-disciplinary course on the mechanical behavior of polymeric composites, sandwich structures, and integrating basic engineering mechanics to study fluid effects. On a personal note, I want to thank Dr. Akawat Siriruk, my former doctoral student and post-doctoral fellow, who has typed this manuscript for Jack while he was battling cancer and did an outstanding job of helping Jack Weitsman to complete this book. Jack dearly loved his wife Bertha and she was instrumental in providing the peace of mind to Jack to complete this book in most challenging health related circumstances.

I do hope that the reader will enjoy the contents and should find the material useful and significant for a long time to come.

Knoxville, TN, USA

Dr. Dayakar Penumadu
Head, Civil and Environmental
Engineering Department
Fred Peebles Professor and JIAM
Chair of Excellence
University of Tennessee, Knoxville

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Weitsman, Y.J.

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