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Book Review

Thermal Stresses V, edited by R. B. Hetnarski. Lastran Corporation, Rochester, NY, 1999. 542 pages. Price: 135.00.

REVIEWED BY D. H. ALLEN[1]

This is the fifth volume in the series edited by R. B. Hetnarski on thermal stresses. While the first four volumes dealt with a variety of diverse issues, the current volume deals primarily with the issue of thermomechanically induced stresses and deformations in composite solids. The text is comprised of four chapters, each written by different authors, and dealing with somewhat different issues in composites. The first two chapters are quite closely related in scope, whereas the final two chapters deal with subjects that are related to the other two chapters, but may be treated separately.

The first chapter is written by C. T. Herakovich and J. Aboudi, both of whom are well known for their past research in composites, especially those that contain at least one inelastic phase. The thrust of this chapter is aimed primarily at stress analysis of metal matrix composites, with special emphasis on three aspects of this subject: micromechanics; lamination theory; and composite structures. Each of these subjects is treated in sufficient detail to be read without referring to additional materials. However, both the first and last emphasize only those methods that the authors were instrumental in formulating over the years.

In the case of micromechanics, the approach described by the authors is the method of cells. Particularly noteworthy in this chapter is the study of yielding of metal matrix composites under multiaxial stress states, a subject in which the authors are at the forefront of research.

The authors then review lamination theory for the case of transient temperatures. In the case of structures, the authors discuss primarily a methodology for modeling composite tubes.

This chapter can be considered to be an introduction to the subject of stress analysis of composites under transient temperature conditions, with emphasis on analytic methods of problem solution.

The second chapter is authored by K. K. Tamma and A. F. Avila. It covers the same issue as chapter one, namely, the prediction of thermally induced stresses in (primarily metal matrix) composites. However, the emphasis in this chapter is on computational techniques of stress analysis. The chapter opens with a lengthy and exhaustive review of computational methods for stress analysis in composites. This section is quite detailed and informative, especially for those who are new to the field. This is followed by two equally useful discussions of various micromechanics models, and several viscoplasticity models for metals. The section on computational methods of structural analysis introduces the finite element method for stress and deformation analysis of solids undergoing thermal transients. The chapter ends with several example calculations for both aluminum and titanium matrix composite structures such as blades in hot gas turbine engines. It is significant to note that such calculations were not possible as recently as twenty years ago. Today, such algorithms are available in numerous commercially available codes, and these calculations are performed routinely as a part of the design process. As such, this chapter presents a concise review of these advances in the last score of years.

The third chapter is written by R. Wojnar, S. Bytner, and A. Galka, all from the Polish Academy of Sciences in Warsaw. This chapter treats an entirely different subject from the first two chapters, dealing with the prediction of effective properties of heterogeneous media. While the emphasis in the current chapter is on homogenization techniques for thermally related properties, other properties such as mechanical, electric, and diffusive properties are also treated.

The scope of this chapter is much narrower than the previous two chapters. Whereas the opening chapters tend to give overviews of a broad field of research, this chapter considers the subject of homogenization theory in great detail. Indeed, to this reviewer's knowledge this is one of the two or three most detailed studies of this important issue in composites. Particularly noteworthy is the historical review that opens the chapter. The authors have taken great care to detail the important events on this subject dating back to the mid 19th century.

The interested reader will find a rigorous review of homogenization theory, and while the treatment is quite mathematical in nature, it is in a notation that is familiar to those who follow this area of research.

The final chapter in the text is written by N. Rajic, of the Aeronautical and Maritime Research Laboratory in Melbourne, Australia. This chapter deals with an important but quite dissimilar topic from the first three. The issue herein centers on the conversion of mechanical energy to heat during plastic deformations and/or crack growth in solids. While this subject was touched upon in previous volumes in this series, the current treatment is a welcome entry to the current text, and due to the emphasis on metal matrix composites in chapters one and two, is well placed in the current volume.

The author reviews the phenomenological description of the thermodynamics of plastic dissipation, and the model is utilized to predict the temperature rise due to a plastic zone near a circular hole in a metallic plate. This discussion is followed by a short section on the prediction of the temperature change induced in a plate by the energy dissipated when a crack runs in a ductile solid. While this chapter is somewhat shorter and less detailed than the others, it is nevertheless inciteful in its treatment of the subject of dissipation.

Despite the fact that there are differing authors, this volume does contain a common scope, which is often not the case in volumes of this type. Furthermore, the assemblage of all of this information into a single volume constitutes at the very least one of the most voluminous treatments of this subject heretofore seen by this reviewer. Thus, the volume would make a quite useful addition to both the reference and educational collections of scientists working in this field.

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