SPECIAL ISSUE

Computational Methods in Composite Materials and Structures

Guest Editors
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PREFACE

Composite materials have become a fundamental component of the manufacturing processes for engineering structures, systems and mechanisms because of their extreme ranges of strength and flexibility. It provides opportunities to design specific and optimal properties that were not available for traditional homogeneous engineering materials. Composites are everywhere from applications in civil and environmental engineering till the very subtle and rare parts and elements in aeronautical and biotechnological applications. This enormous progress, comparable to the technological revolution of the eighteen century, was possible thanks to the academic and industrial research in development, design, optimization and modeling of multi-component materials. A larger part of this development was possible due to the tremendous progress of computer methods and modeling techniques including Finite Element, numerical methods as well as advances in homogenization methods. Research directions in the area of composite materials often follow preceding discoveries and new ideas in classical mechanics, physics, and chemistry of solids. One of the most eminent and recent examples is the analysis of nano-composites, which reflects an impact of academic and industrial research in nanosciences noticed a few years before. The second source of composites research expansion is the variety of the autonomous problems still arising in the case of multi-component materials like the interface phenomena, which do not take place in homogeneous materials. Another source of innovation lies in the development of computational methods by themselves; like progress in stochastic numerical analysis of composite's durability and reliability.

Considering a number of new directions, ideas and methods, we summarize the current progress in computational analysis of composites to identify important engineering problems to be modeled and solved in this area and to provide an overview of new mathematical methods that can be implemented into existing computer codes. This issue, containing the papers presented at the Eight World Congress of Computational Mechanics (WCCM 8) and Fifth European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008) held in July of 2008 at Venice in Italy, has been compiled for this purpose. This issue contains selected papers, which according to the opinions of all reviewers are the representative of current research in composites science and engineering. The leading idea in all these works is to answer the fundamental question – *how is the overall composite behavior governed by smaller scales phenomena?*

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According to the previous comments, an important part of today's investigations belongs to multiscale analyses, including atomistic scale, of fracture resistance of SiC-Si3N4 nanocomposites which is reported in the paper by *Tomar* and *Samvedi*. Crack propagation and evolution of the microstructure are analyzed. Quite a similar viewpoint is presented in the work of *Lauke* and *Morozov*, where the mechanisms of particle interaction are incorporated for a prediction of the filled elastomers' overall behavior under a uniaxial elongation. In his study, *Abu Al-Rub* proposes higher-order gradient plasticity theory to incorporate the effects of particle sizes and particle-matrix interface characteristics on the effective plastic behaviors of metal matrix composites with particle inclusions. Next, we change the scale to the larger one, where one may imagine, the particles should influence the interface phenomena in composites. Some of the important phenomena are crack formation and propagation as well as their computational modeling of the extended Finite Element Method (XFEM) presented by *Chudoba*, *Jerabek* and *Peiffer* for a two-phase textile reinforced composite. The next study by *David* and *Gao* is performed at the fiber scale but also discusses the dependence between the molecules architecture, interactions and the global fiber behavior. The authors demonstrate the application of their viscoelastic fiber model to analyze ballistic behavior of fabrics made of Twaron® CT716 at various strain rates. The viscoelastic analysis made in conjunction with the thermal processes is presented by *Sawant* and *Muliana* in their advanced micromechanical computational modeling of kevlar-epoxy composite with stress- and temperature-dependent properties. The remaining papers by *Kanaun* and *Kamiski* are devoted to the interaction between micro- and macro-scale of the composite. The first paper is focused on the theoretical studies, where the analytical solutions to the integral equations for effective strain fields in a heterogeneous medium are found. Contrary to that, *Kamiski* presents a computational simulation, where the stochastic aging processes of the fiber and the matrix influence the aging effects in the effective properties of the glass-epoxy composites. Therefore, from elastic to the viscoelastic, from deterministic to the stochastic as well as from the molecular scale to the macro one, we have an overview of the applications of the computer methods in composites engineering.

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