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Editorial

Modelling and Optimizing Structural Behavior of Advanced Materials for Aerospace

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Aeronautics and aerospace face great pressure for ever increasing performance and efficiency while ensuring maximum reliability and controlling costs. Material selection, structural design, and fabrication methods play a central role among many different contributions for achieving those objectives.

The main metallic materials have been Al alloys, where the introduction of special alloying (Li, Sc, etc.) may substantially improve performance, and Ti alloys playing an increasingly important role because of their corrosion performance. The trends for additive manufacturing (AM) imply that components may become simpler, reducing weight and part count, a trend that is also supported by fabrication techniques as friction stir welding or laser beam welding leading to integral structures.

Among composites, thin ply laminates and design of composites for specific performance are the object of continuing interest and progress. Joining and adhesive technology is an important area where improved structural performance and durability are expected.

Open problems exist in all those areas, as exemplified by the assurance of integrity and mechanical performance of AM parts or the improvement of composite structure fabrication through reduction of shimming and other nonadded value operations.

The understanding of the mechanical behavior and its incorporation into design practice is made through structural analysis, and this subject is also of interest for this special issue. Computational mechanics has progressed from the traditional FEM and DBEM approaches to combined/hybrid and multiscale analyses that may accurately model and predict crack paths and damage within controlled computational effort. Some complications arise when considering modelling of crack propagation in orthotropic materials like single crystal and directionally solidified polycrystalline components (typical application in first-stage aircraft turbines).

The purpose of this special issue is to draw attention of the scientific community to recent advances in modelling and optimizing structural behavior of advanced materials for aerospace and their possible applications.

In this special issue researchers contributed original research articles as well as review articles on modelling and optimizing structural behavior and damage of advanced materials used in aeronautics and aerospace, also considering nondestructive testing and evaluation.

Theoretical, numerical, and experimental contributions describing original research results and innovative concepts on aeronautical and aerospace materials and structures were collected.

The special issue includes several high-quality papers written by leading and emerging specialists in the field.

13 submissions have been received. Among the articles collected, a number of high-quality papers existed, which led to 6 published articles.

A very short description of the addressed topics, in the order of themes cited below, is presented as follows:

In "Numerical-Experimental Assessment of a Hybrid FE-MB Model of an Aircraft Seat Sled Test" by F. Caputo et al., the development of an established hybrid multibody- (MB-) finite element (FE) model for the simulation of an experimental sled test was provided. The numerical investigation was carried out by focusing on the passenger passive safety: the occupant injury assessment was quantitatively monitored by means of the Head Injury Criterion (HIC). Numerical results provided by the hybrid model proposed in the paper were compared with the experimental ones, provided by Geven S.p.A. company, and with the results carried out by a previously developed full-FE model, showing a good level of consistency vs. experimental results and a significant reduction of computing time vs. full-FE analyses.

In "Optimization of Hybrid Laminates with Extension-Shear coupling" by D. Cui and D. Li, the expressions of stiffness coefficient, thermal stress, and thermal moment for hybrid laminates were derived based on the geometrical factors of laminates, and the necessary and sufficient conditions for the hybrid extension-shear coupled laminates with immunity to hygrothermal shear distortion (HTSD) were further derived. The extension-shear coupled effect of hybrid laminates was optimized with improved differential evolution algorithm. Results were presented for hybrid laminates made of carbon fiber and glass fiber composite material. The hygrothermal effect and extension-shear coupled effect were simulated and verified, and the robustness of hybrid laminates was analyzed by Monte Carlo method.

In "Aeronautical and Aerospace Material and Structural Damages to Failures: Theoretical Concepts" by A. V. Goncharenko, the multioptionality hybrid function uncertainty conditional optimization was implemented for a degrading failure problem optimal solution determination. The principal supposition was that there should have been some certain objectively existing value extremized in the conditions of the hybrid-optional function uncertainty. The described doctrine allowed obtaining the objectively existing optimal values with the help of a not probabilistic rather multioptimal concept. Applying simplified, however possible, models and expressions for effectiveness, plausible results were obtained, illustrated in diagrams, and allowed taking a good choice.

In "Analytical Study on Deformation and Structural Safety of Parafoil" by L. Wang and W. He, the cell bump distortion and bearing capacity of parafoil structure was analyzed. Based on the mechanical properties of the membrane structure, the spanwise model of parafoil inflation was established and verified by comparing with the fluid-structure interaction (FSI) results. The analytical model was proved to be useful for the weakening deformation design and the safety discussion of large parafoil for rocket booster recovery.

In "Effective Mechanical Property Estimation of Composite Solid Propellants Based on VCFEM" by L. Shen et al., the structural integrity of propellant grain was estimated by a numerical method that combines the Voronoi cell finite element method (VCFEM) and the homogenization method. The correctness of this combined method was validated by comparing with a standard finite element method and conventional theoretical models. The microscopic numerical analysis method proposed in this paper could also be used to provide references for the design and the analysis of other large volume fraction composite materials.

In "Application of a Cohesive Zone Model for Simulating Fatigue Crack Growth from Moderate to High ΔK Levels of Inconel 718" by H. Li et al., a cyclic cohesive zone model was applied to characterize the fatigue crack growth behavior of a IN718 superalloy which is frequently used in aerospace components. The gradual loss of the stress-bearing ability of the material was considered through the degradation of a novel cohesive envelope. The experimental data of cracked specimens were used to validate the simulation result. Based on the reasonable estimation for the model parameters, the fatigue crack growth from moderate to high ΔK levels could be reproduced under the small-scale yielding condition, which was in fair agreement with the experimental results.

Acknowledgments

The editors would like to express their thanks to all authors of the special issue for their valuable contributions and to all reviewers for their useful efforts to provide valuable reviews. We expect this special issue offers a timely view of advanced topics in structural behavior of advanced materials for aerospace, which will grant stimulation for further novel academic researches and innovative applications.

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