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Editorial

Special Issue "Composite Materials in Design Processes"

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Composite materials have been used in design since antiquity, as the description of the Ulises' arch in the Odyssey suggests [1]. The great advantage provided by the use of composite materials in the design process is that it allows tailoring the mechanical properties of the components, in order to obtain the highest specific strength or stiffness and, consequently, reduce the overall weight. The possible combinations of matrix, reinforcement, and technologies, on the one hand, provide many more options to the designer and, on the other hand, widen the fields that need to be investigated to obtain all the information requested for a safe design.

This Special Issue contains a variety of approaches aimed to draw directions for the designers of applications characterized by different technology readiness levels, at different dimensional scales and technological process phases.

Design of the material: A number of papers may be categorized in this way, from different points of view. In [2], the toughening of the matrix through polymeric nano veils is described. This is a popular research topic because employing low-cost electrospinning technology is easily possible to obtain non-woven nanostructured veils starting from different liquid polymers. The research activity is based on the relatively recent review presented in [3], and since then, different research groups have provided results in this field [4–7].

In [8], the concept is widened, since the epoxy resin is reinforced by a microcapsule system to achieve a self-healing goal. In this case, there are no reinforcing fibers, because the role of the epoxy resin is functional (i.e., electrical insulation) and not structural; nevertheless, the authors obtained a very promising repair efficiency and rate.

The papers [9,10] consider two different aspects of interleaving viscoelastic materials between long fiber reinforced plastics layers. In fact, while [9] focuses the attention on the positive effect of macroscopic viscoelastic elements on the slamming damage in Glass Fiber Reinforced Plastics (GFRP), in [10], thin viscoelastic layers are interleaved with Carbon Fiber Reinforced Plastics (CFRP) plies in order to improve the damping properties of the laminate.

Differently from the previously mentioned ones that focus on matrix properties modification, the works [11,12] are more related to fibers. In [11], several methods for measuring the fiber content in naval applications are shown. This is of paramount importance for design purposes, since the fiber fraction is the quantity most of the mechanical properties are most sensitive to, according to the rule of mixtures. On the other hand, in [12], an analytical model is proposed and experimentally validated to describe the shear behavior of fabrics with different weave patterns, in which tension-shear coupling is considered. This is done under large shear deformation.

Improvement of the technological processes: Dealing with composite materials, it is not possible to separate the material properties from the technological production processes. In [13,14], two dry fiber techniques are studied. In particular, [13] shows the numerical simulation of the channel distribution in a liquid resin infusion using an approach similar to the one reported in [15]. Differently, [14] presents an experimental activity on the resin transfer molding process following the previous activities on the topic [16,17] of the research group. The papers [18,19] focus on the electric deposition of composite coatings and coupled waterjet and laser surface treatments.

Structural design methods: Even if just one paper belongs to this category [20], it is described separately because it is the one dealing with applications at TRL6 or higher and contains numerical and experimental analysis. Moreover, a synthesis of a complete design and fabrication of an automotive part, in particular the photovoltaic panel of a solar vehicle, is presented. The general requirements of this class of vehicles are described in [21], while the design process for the structure and some mechanical components can be found in [22–25]. The paper contained in this Special Issue deals with a multi-objective design optimization in which not only the lamination sequence but also the topology of the component is modified to obtain optimum performances.

Research directions: This Special Issue touched several hot research topics showing that, to improve how designers can use composite materials, different activities are needed. New functional properties may be sought for maintaining or improving material mechanical performances; while low cost, high-volume processes would open a wider market for composite components, so this is a further wide research field; finally, general topological optimization methods for layered materials will allow us to reduce the weight in the most advanced sport of aerospace applications further.

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