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Editorial

Editorial for the Special Issue on Discontinuous Fiber Composites

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The papers published in this special edition of the *Journal of Composites Science* will give the polymer engineer and scientist insight into what the existing challenges are in the discontinuous fiber composites field, and how these challenges are being addressed by the research community. The papers present a balance between academic and industrial research, and clearly reflect the collaborative work that exists between the two communities, in a joint effort to solve the existing problems.

Discontinuous fiber-reinforced composites are a special subcategory of composite materials that are used, due to the ability to process them into parts and structures of complex shape in an automated fashion via compression and injection molding, as well as extrusion processes. Discontinuous fiber-reinforced composites commonly consist of a thermoset or thermoplastic matrix material. Sheet molding compound (SMC) is the most prominent type of discontinuous fiber-reinforced thermoset and is processed using compression molding to manufacture automotive body panels and structures. Schemmann et a. [1] designed various test specimens to measure the mechanical behavior of SMC under biaxial loading, and Trauth et al. [2] studied the effect of volume fracture and SMC semi-finished charge manufacturing conditions on the mechanical properties of the molded parts. A variety of thermoplastic matrices and processes are also available for discontinuous fiber-reinforced composites. Thermoplastics, such as polyamide (PA) or polypropylene (PP), represent most matrix materials used for thermoplastic fiber reinforced parts due to their superior properties compared to other plastics. Glass fibers are frequently used for reinforcement due to their availability, low cost and high strength, although carbon fibers are also being implemented [3], as well as natural [4] and basalt [5] fibers. Discontinuous fiber-reinforced composites can be further classified as short fiber-reinforced thermoplastics (SFT) and long fiber-reinforced thermoplastics (LFT). The distinction between LFT and SFT is made by the average fiber aspect ratio (length to diameter). A fiber-filled material with an average aspect ratio of less than 100 is defined as short fiber-reinforced, while long fiber-reinforced composites have an average aspect ratio of more than 100. The performance and cost of LFT materials places them between continuous fiber-reinforced composites used for high performance applications and SFT compounds, because LFT can be processed economically with injection molding, while providing superior mechanical properties when compared to SFT. Often, products present a combination of continuous and discontinuous fiber composite systems [6], such as in the growing field of hybrid structures. Here, draped continuous fiber structures are over-molded with discontinuous fiber-filled resins, synergistically creating parts with superior mechanical properties.

The processing of discontinuous fiber-reinforced composites, such as mold filling in injection molding, or flow through the nozzle during fused filament fabrication, has a profound impact on the arrangement of the fibers within the finished part. As fiber filled polymers are shaped into the final part geometry, the fibers are not only oriented [2,3,7–11], but they are also broken down [4] and agglomerated [12], resulting in highly anisotropic products. While the anisotropy can be beneficial, when the fibers are aligned in the direction of highest stresses, most design processes of discontinuous fiber-reinforced composites parts do not consider all aspects of the process-microstructure-property relationship. Several papers in this issue relate mechanical properties to fiber microstructure [1–3,5,7,9,10] and the paper by Wang and Smith [10] relate the microstructure to rheological behavior. Not incorporating the effect of fiber microstructure can result in larger safety factors, which leads to higher weight than necessary, limiting the application of this class of materials. Although discontinuous fiber composites have been used for decades, the underlying physics that control fiber attrition, fiber matrix separation, and even fiber alignment are not fully understood. Without the ability to predict and fully control the fiber microstructure within the final product, the full potential of discontinuous fiber reinforced plastics for lightweight applications cannot be achieved.

Structural analysis can only provide accurate results if the fiber microstructure is estimated accurately. Today, a handful of software companies offer a wide range of tools to predict fiber microstructure which is helpful during the design process of discontinuous fiber-reinforced composites. One can say that these tools are constantly under development and continuously being improved. These tools are indispensable to industry, as parts made of composites for automotive and aerospace are required to go through a comprehensive numerical analysis and design process before being considered for production.

To fully exploit the full potential of discontinuous fiber filled polymer composite materials, it is crucial that the engineer controls and predicts the structural capabilities of fiber-reinforced molded parts, including the configuration of the fibers. Only by adequately incorporating the process-induced fiber microstructure in the design process will it be possible to achieve a reliable prediction of the performance of the molded part. The collection of papers in this issue may help advance technology and bring industry closer to understanding the underlying phenomena that control the microstructure development during processing of discontinuous fiber filled systems, and thus being able to confidently implement them into lightweight applications.

Conflicts of Interest: The authors declare no conflict of interest.

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