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Additive manufacturing of multifunctional composites for aerospace applications: Large-scale, non-planar and multi-process

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ABSTRACT

Our research focuses on the development of high-productivity additive manufacturing (AM) processes through several R&D projects in collaboration with our aerospace industrial partners located in Canada and in France. We have developed expertise in the design of advanced AM processes (see Figure 1) that enable large-scale non-planar printing of various polymer-based composites mainly for aerospace, but also for biomedical and energy-harvesting applications. One of our unique AM processes involves a six-axis robotic arm on which various types of AM printheads can be installed. This infrastructure enabled the rapid nonplanar multinozzle direct deposition of thermosetting abradable materials for sound absorption of aircraft engines. For the printing of thermoplastics, we integrated the prevalent Fused Filament Fabrication (FFF) process into the same 6-axis robotic platform for non-planar printing of geometrically-optimized sandwich structures using high-temperature-resistant thermoplastic composites such as carbon fiber-reinforced polyetherimide (PEI) and polyetheretherketone (PEEK). Our very recent efforts are focused on the development of a high-throughput AM process based on Fused Granulate Fabrication (FGF) using a pellet-extrusion printhead. Our experimental works on the manufacturing side are supported by numerical simulations. For example, we have created finite element models with element activation based on the manufacturing G-code instructions to predict the heat exchanges during the printing process. In addition, the phase-field modeling approach is used for the crack initiation and propagation predictions within 3D printed composites. We are also investigating the circular economy of materials in the FFF and FGF processes. Our preliminary results are providing comprehensive insights into the sustainability of fiber-reinforced thermoplastic composites for future aerospace applications.