PRINTING CRITERIA FOR MATERIAL EXTRUSION OF HIGH TEMPERATURE THERMOPLASTIC COMPOSITES

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Over the last decade, the popularity of 3D printing has increased dramatically. Material extrusion (ME) is the most common type of 3D printing, which typically involves extruding a molten thermoplastic material through a small orifice in a specific pattern. Once considered only a technique for making non-functional prototypes, a wide range of ME systems are now using high performance materials for a variety of functional applications. However, the process science underlying the extrusion of these materials is not well understood. Therefore, the authors have developed a “printability” framework for evaluating extrusion-based printing criteria for a wide range of thermoplastic materials based on fundamental viscoelastic and thermo-mechanical properties. The framework establishes processing boundary conditions for the four basic modes of the ME process: pressure-driven extrusion, extruded geometry definition, geometry stability, and component integrity. The governing equations for each of these modes have been applied to a variety of high performance materials across a number of ME-based printing platforms, including the large-scale 3D printing of carbon fiber reinforced composites.

![Figure 1 – Primary modes of material extrusion printability model](image-url)

(1) Material Extrusion
(a) Pressure Flow
(b) Fiber Clog

(II) Geometry
(a) Creation
(b) Stability

(III) Functional Bead
(a) Bridging
(b) Substrate
(c) Wall

(IV) Component
(a) Distortion
(b) Cracking