Sintering-Assisted Additive Manufacturing

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The specific structures of powder materials produced through additive manufacturing methods (such as binder-jetting, stereolithography, robocasting, and selective laser sintering) for complex-shaped components require careful optimization of the sintering process for porous 3D-printed products. Optimizing the additive manufacturing process for green parts enhances the final product quality by reducing shape distortions, surface roughness, and residual porosity, as well as improving the subsequent sintering steps. The sintering stage demands a thorough understanding of the high-temperature deformation behavior of the 3D-printed porous specimens. In particular, the effects of fabrication directionality and gravity on the micro- and macro-structure of sintered components remain poorly understood. Ensuring the densification of complex shapes involves controlling gravity-related and anisotropic phenomena to achieve nearly complete and distortion-free densification. Therefore, the unique features of 3D-printed microstructures necessitate the development or modification of sintering theories. The studies conducted address these challenges by involving modified sintering constitutive models, comprehensive finite element simulations, and experimental validation of the developed models. These models describe the sintering of 3D-printed objects in comparison to conventionally produced porous sintering preforms. Validation of the developed models is achieved through comparison with experimental results obtained from sintering printed powder ceramic and metallic components. The findings demonstrate how analytical engineering criteria, applicable to the design recommendations for sintered 3D-printed parts, can be derived.