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Viscous Sintering Kinetics in Fused Deposition Modeling: From Microstructural Evolution to Interlayer Bonding

Interlayer bonding in Fused Deposition Modeling (FDM) is governed by viscous sintering–driven coalescence of adjacent polymer filaments, which controls porosity evolution and mechanical integrity. However, a quantitative description linking material rheology, processing conditions, and neck growth kinetics remains incomplete. In this work, a physics-based theoretical model is developed to describe viscous sintering dynamics between neighboring extruded filaments under surface-tension-driven viscous flow. The model captures the time-dependent evolution of neck radius and bonding area, enabling the derivation of quantitative scaling relations for interlayer densification as functions of viscosity, surface tension, and filament geometry. Model predictions are validated against experimental microstructural data reported in the literature, showing strong agreement in both neck growth kinetics and bonding area evolution. The analysis reveals governing laws of viscosity-controlled densification in FDM and identifies key parameters regulating the sintering rate under practical printing conditions. The bonding interface evolution is further identified as a physically meaningful metric for assessing interlayer structural integrity. This study provides a validated framework for analyzing viscous sintering in FDM and offers a physical basis for predicting porosity evolution and mechanical performance, enabling process optimization for high-performance additively manufactured components.

Professional Status of the Speaker

Doctoral or Master Student

Interest in submitting a paper in a special issue of

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Invitation letter for visa

Yes

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