Development of a multi-phase viscoelastic solver for polymer based additive manufacturing simulation

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Abstract

Among the many mature and commercial AM technologies, fused deposition modeling (FDM) is a popular technology commonly used for modeling, prototyping, and production applications. In this process, a filament thermoplastic material is fed into a liquefier chamber, melted to a liquid state, and deposited layer by layer through a nozzle to form the 3D part. Part quality and manufacturing time however remains a key barrier for large scale industry adoption. The uncertainly of the final part dimension (i.e. warping, distortion, delamination, etc.) and the uncertain resultant mechanical properties hinder wider application of this technique.

In FDM, a large number of processing parameters in combination with the properties of the deposited material influence the final part quality such as residual stress distribution, degree of distortion, surface finish, etc. Key processing conditions include the working temperature, envelop temperature, pressure, feed speed, nozzle diameter and shape, road width, deposited layer thickness and tool path. In this study, we have developed a viscoelastic multi-phase solver, with capability for dynamic meshing and based on OpenFOAM. The solver directly simulates the deposition process of FDM. By implementing this solver for different boundary conditions and geometry, we are capable of evaluating the printed part quality for varied processing conditions. More importantly, the tool enables efficient optimization of the processing conditions for specified material parameters and desired print quality.

Keywords: Additive manufacturing, fused deposition modeling, processing conditions, viscoelastic multi-phase solver, OpenFOAM