

ROBUST DESIGN OF MIXING ELEMENTS FOR PLASTIC EXTRUDERS

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ABSTRACT

Ubiquitous manufacturing processes for plastics, such as extrusion or injection molding, rely on the generation of thermally and mechanically homogeneous melt flows to produce high-quality final products. In addition to the uncertainties inherent to real-world processing conditions, the need to use increasingly higher contents of recycled plastics, driven by environmental considerations, introduces further challenges. Recycled feedstocks exhibit greater batch-to-batch variability and higher levels of impurities, which in turn necessitate more robust manufacturing processes.

This work explores the viability of designing the mixing sections of plastic extruders within a robust optimization framework. The plastic melt flow is modeled using Stokes equations and a non-Newtonian constitutive law, with model parameters subject to uncertainties arising from the variations in the input materials. To evaluate the performance of the mixing elements attached to the extruder screw, we employ an objective function based on a measure for the interfacial area in the extruder outlet flow. The high computational cost associated with repeated forward simulations is alleviated through the construction of a surrogate model that relates the design parameters to the objective function using Gaussian process regression. In a hybrid approach, the regression model is initially trained and subsequently adaptively refined during the optimization process through evaluations of the high-fidelity simulation model near critical points.

Besides quantifying the impact of the uncertainties in the input material properties on mixing performance, in this talk, we investigate how these uncertainties affect the resulting robust design and its ability to generate uniform melt flows.