Material Properties in Ceramic Injection Molding Design

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Abstract

Ceramic injection molding (CIM) is a high volume, near net shaping process used to manufacture ceramic parts with complex features and shapes. In CIM design it is important to understand the molding behavior as a function of powder-polymer (feedstock) composition in order to achieve desired part dimensions and properties, at high production rates. Standard practices in CIM product design typically involve performing multiple trial-and-error molding experiments for various feedstock compositions. Alternatively, CIM design simulations can be performed to reduce the iterations. However, they require the measurement of physical, thermal and rheological feedstock properties and the availability of such data is limited. Currently there is no reliable design approach available to perform mold-filling simulations for compositions that differ from those with measured feedstock properties. The present work develops and evaluates a new method to estimate feedstock properties critical to performing CIM simulations. The method utilizes the material properties of ceramic fillers from literature along with experimental measurements of an unfilled wax-polymer binder system.

The current work is divided into three parts. In the first part, nine different ceramic feedstocks and a wax-polymer binder, whose material properties were measured by our research group, formed the basis for this study. Experimental and estimated feedstock properties of these nine systems were compared to quantitatively evaluate the quality of correspondence. The second part uses the measured and estimated physical, thermal, and rheological properties for an aluminum nitride feedstock to perform mold-filling simulations to compare the differences in the output of CIM simulations based on the input feedstock property data from experiments and estimates. The third part examines the merits of CIM simulations to predict mold-filling behavior by conducting injection-molding experiments for an aluminum nitride feedstock. The findings from the current study can be used to improve CIM design practices and serve as a guide for estimating ceramic feedstock properties to conduct mold-filling simulations.

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