ABSTRACT

Additive manufacturing (AM) shows great potential for fabricating parts with complex geometries, including energetic composites (ECs). Although promising, there are fracture toughness concerns due to internal interfaces, or "welds," formed during the AM process. Mechanical robustness is imperative if AM is to become a common technique for production. This research uses conventional and novel fracture characterization techniques to understand the fracture behavior of ECs and explore how the AM process affects the fracture properties of the final part. Pure shear tearing experiments are conducted with mock ECs to develop relationships describing how particle concentration and size distribution impact fracture toughness. The Soft-matter, Low-friction, Y-shaped Cutting Experimental Rig (SLYCER) is designed and manufactured to perform spatially targeted fracture characterization experiments. Y-shaped cutting is performed using the SLYCER on a mechanophore-incorporated binder system to highlight fracture phenomena not captured by classical expectations. Results from cutting of the mechanophore-incorporated binder validate that the large deformation zone near the crack tip during cutting is small, a necessity for targeting internal geometric features in AM parts. Finally, Y-shaped cutting is performed on vibration-assisted printing produced mock ECs, targeting different features of internal geometry to assess fracture toughness differences in a single part. The welds exhibit lower fracture toughness than non-interfacial regions like the printed roads. Potential factors leading to this difference in behavior are observed and discussed. These findings provide important information on potential improvements to the additive manufacturing process necessary to ensure mechanical robustness of ECs produced in that fashion, moving closer towards commercialization.