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Resin Properties and Part Size Interrelationships in Computed Tomography-Based Volumetric Additive Manufacturing

Amir H. Behravesh[1], Asra Tariq[1], Ghaus Rizvi[1*]
1: Faculty of Engineering and Applied Science, Ontario Tech University, Canada
*Corresponding Author: Ghaus.Rizvi@ontariotechu.ca

Abstract

Volumetric additive manufacturing (VAM) is an advanced additive manufacturing technique that enables the rapid formation of an object by simultaneously curing an entire volume of resin. Unlike traditional layer-by-layer 3D printing, VAM offers superfast printing speed, isotropic mechanical properties, and the ability to print complex geometries without the need for support structures. In the last few years, researchers worked on refining the VAM process to improve printing resolution, accuracy, and material versatility. Researchers have explored various aspects, such as optimizing light projection methods, image processing, understanding photopolymerization kinetics, and developing new photocurable materials tailored for this method. One limitation of this manufacturing process is the size of the printed object. The main issue addressed in this study is the assessment of the dimensional limitation of the printed object produced in the VAM process. An analytical model is introduced to predict the product size based on the resin property (penetration depth -D_p), container size (radius), and the duration of part formation. The results indicate significant correlations among these parameters. Experimental verification of the developed mathematical correlation is done. Multiple criteria are also introduced for selecting the appropriate size of resin container based on the desired object size and the value of D_p. It was found that the D_p plays a critical role in both the analysis and experimental of the VAM process, and its action and value are significantly different from the one obtained by the conventional AM polymerization methods, such as DLP and SLA. The experimental results closely align with the analytical predictions, validating the accuracy and reliability of the analytical approach.