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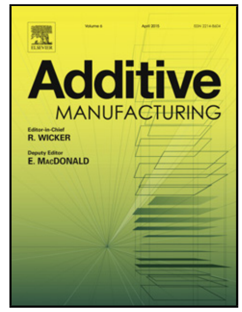

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Author: Yayue Pan Yong Chen

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<AT>Meniscus Process Optimization for Smooth Surface Fabrication in Stereolithography

<AU>Yayue Pan[a*] ##Email##yayuepan@uic.edu##/Email##, Yong Chen[b]
<AU>
<AFF>[a]842 W. Taylor St., ERF 2309, Department of Mechanical and Industrial Engineering University of Illinois at Chicago, Chicago, IL 60607, USA
<AFF>[b]3715 McClintock Ave, GER 240, Epstein Department of Industrial and Systems Engineering
<AFF>University of Southern California, Los Angeles, CA 90089, USA

<PA>*Corresponding author at.: Tel.: (312) 996-8777.

<ABS-HEAD>Abstract

<ABS-P>In the layer-based additive manufacturing processes, it is well known that the surface finish is usually poor due to the stair-stepping effect. In our previous study, it was shown that the meniscus approach can be used in the Stereolithography process to achieve much better surface finish. A related challenge is how to optimize parameters such that the formed meniscuses can lead to high surface finish and accurate shape. In this paper, a systematic process planning method is presented for the Stereolithography process that is integrated with the meniscus approach. Process planning, parameters characterization and meniscus parameters optimization are presented with experimental verifications. To demonstrate the systematic process, surface profile simulation, meniscus database construction, meniscus forming parameter optimization, and shape accuracy prediction have been performed using a test case based on convex surfaces. A comparison between the experimental results with and without the process planning method is presented, illustrating the effectiveness of the developed meniscus optimization method in simultaneously controlling the shape and surface finish of fabricated objects. Subsequently the simulation results are also verified with experimental results.

<KWD>Keywords: Stereolithography; surface finish; meniscus; accuracy; process optimization.

<H1>1. Introduction

Stereolithography (SL) Apparatus is the first commercialized Additive Manufacturing (AM) technology and also one of the most commonly used AM technologies [1-3]. In SL process, liquid photosensitive resin is cured by light irradiation, usually through the use of a UV laser beam or a Digital Light Projection (DLP) system that uses a Digital Micromirror Device (DMD). Controlled light irradiation induces a curing reaction, forming a highly cross-linked polymer. Compared to other polymer-based AM technologies such as the extrusion or jetting based processes, the SL process can produce parts with fine features, good accuracy, and using various polymers [4-9]. SL also surpasses the processing speed and yields of subtractive-type mask-based processing [10] as well as other micro-patterning processes [11]. Its potential applications in three dimensional (3D) structure fabrications include prototyping, tooling and manufacturing, medical devices, artwork, and architectures, to name a few. A schematic diagram of a Mask Image Projection based Stereolithography (MIP-SL) system is shown in Fig.1 (a).

Similar to other additive manufacturing processes, the objects fabricated by the SL process also have stair-stepping effect due to the use of two-dimensional (2D) layers [11-13]. As shown in Fig. 1 (b)-(d), a given 3D model is first sliced into a set of 2D layers. By stacking the sliced 2D layers together, a physical object can be fabricated to approximate the original Computer-aided Design (CAD) model. Due to the stacking of 2D layers, the fabricated curved surfaces especially the ones whose normals are close to the building direction (Z axis) may have