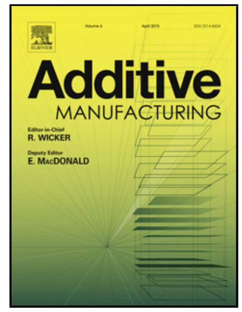

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On Anisotropy, Strain Rate and Size Effects in Vat Photopolymerization Based Specimens

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Abstract

The influence of build orientation, layer thickness, strain rate and size effect on the Young's modulus, ultimate tensile strength and fracture strains in vat photopolymerization based additively manufactured specimens is investigated. Mechanical testing and subsequent scanning electron microscopy tests on additively manufactured specimens are conducted. Anisotropy in mechanical behavior is only observed in specimens fabricated in different planes. An increase in layer thickness and decrease in strain rate resulted in lower strength, stiffness and higher fracture strains. No significant size effect on strength and failure strains is observed. Cure kinetics is found to have significant influence on mechanical properties of additively manufactured specimens.

Keywords: Anisotropy; Mechanical Properties; Fractography; Cure; Vat Photopolymerization.

1. Introduction

Additive manufacturing (AM), also referred to as rapid prototyping, is an emerging technology which uses an additive approach for fabrication of finished products, unlike the conventional manufacturing process that is based on subtractive approach which involves cutting of raw material to create desired parts [1, 2]. In an additive approach, final parts are fabricated by stacking material in layers, where each layer builds the cross-section of a fabricated part. The advent of this approach can be traced back to early 1980's when the patent for stereolithography (SL) was filed by Charles Hull [1, 3]. Powder Bed Fusion, Material Extrusion, Vat Photopolymerization, Sheet Lamination and Directed Energy Deposition are some of the available additive manufacturing techniques [1, 2]. The specific advantages of these AM techniques over conventional manufacturing methods include rapid prototyping, low cost, less material wastage, ease of building assembly free complex 3D objects etc. [1, 2, 4]. These advantages make AM an attractive option for a wide range of applications in the industries related to aerospace, electronics, education, tissue engineering, dentistry, orthodontics, forensics, sporting goods etc. [2, 5-10]. Especially, in the case of bio medical field, customizable tissue scaffolds, jaw implants, medical devices that have complex 3D geometry are currently being built using AM techniques [9, 11-13]. Keeping in view the applications of AM, recent research efforts were directed towards improving the mechanical properties of additively manufactured parts by using appropriate reinforcements [14], [15], [16,