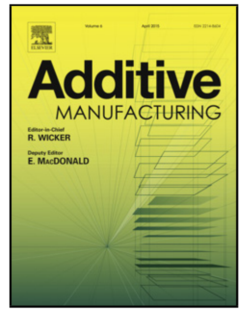
Accepted Manuscript



Title: Investigation of Mechanical Anisotropy of the Fused Filament Fabrication Process via Customized Tool Path Generation

Authors: Carsten Koch, Luke Van Hulle, Natalie Rudolph

PII: S2214-8604(17)30046-5
DOI: http://dx.doi.org/doi:10.1016/j.addma.2017.06.003
Reference: ADDMA 183

To appear in:

Received date: 2-2-2017
Revised date: 9-5-2017
Accepted date: 14-6-2017

Investigation of Mechanical Anisotropy of the Fused Filament Fabrication Process via Customized Tool Path Generation

Author: 1. Carsten Koch[1]

E-Mail: koch7@wisc.edu

2. Luke Van Hulle **(Corresponding Author)** [1]

E-Mail: **lvanhulle@wisc.edu**

3. Professor Natalie Rudolph[1]

E-Mail: **natalie.rudolph@wisc.edu**

[1] Affiliation Address: University of Wisconsin-Madison

1513 University Ave

53706, Madison

USA

Abstract

To aid in the transition of 3D printed parts from prototypes to functional products it is necessary to investigate the mechanical anisotropy induced by the Fused Filament Fabrication (FFF) process. Since the mechanical properties of an FFF part are most greatly affected by the bead orientation and printed density, or solidity ratio, techniques to precisely control these variables are required. An open source Python program, SciSlice, was developed to create the desired tool paths/layer orientations and convert them into machine commands (e.g. G-Code). SciSlice was then used to develop tool paths which either directly printed tensile specimens or printed sheets from which specimens could be water-jet cut. The effects of proper bed leveling and feed wheel adjustment are noted and a careful analysis of both bead orientation and solidity ratio are presented. Printing artifacts related to turns made at the part edges are discussed having been found to have strong effects on the measure strength in the weakest orientation. Finally, it is shown that with proper bead orientation, low layer heights, and a maximum solidity ratio, tensile strengths within 3% of injection molded parts are achievable.

1 Introduction

One of the most common Additive Manufacturing (AM) Material Extrusion (ME) technologies is Fused Filament Fabrication (FFF), commonly referred to by the trademarked name Fused Deposition Modeling™ (FDM™). The process begins to address the challenges of a changing economy and its production requirements. FFF is advancing in its capabilities and material variation and is currently used to manufacture prototypes or small series of specialized parts in various application areas.

FFF is usually compared to injection molding (IM) and in this comparison is often thought to have reduced but unquantified mechanical properties. Therefore, the FFF process needs to be analyzed in detail to understand the contribution of each parameter on the print result. Optimizing the mechanical strength of a printed part may advance the application area of FFF. High solidity parts with the proper build settings can meet the requirements of increased part reliability and strength. However, the resulting 3D components exhibit extensive anisotropy in their mechanical properties. To better characterize this anisotropy, the focus of this study is on crucial print parameters and their effects on the part's mechanical properties, namely ultimate tensile strength.