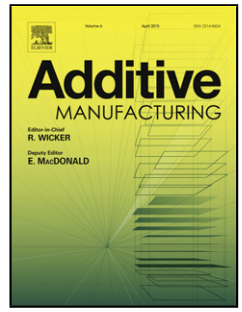
Accepted Manuscript



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Author: Yu-an Jin Hui Li Yong He Jian-zhong Fu

PII: S2214-8604(15)00051-2
DOI: http://dx.doi.org/doi:10.1016/j.addma.2015.10.001
Reference: ADDMA 54

To appear in:

Received date: 16-2-2015
Revised date: 7-4-2015
Accepted date: 8-10-2015

Please cite this article as: Jin Y-a, Li H, He Y, Fu J-z, Quantitative analysis of surface profile in fused deposition modeling, *Addit Manuf* (2015), http://dx.doi.org/10.1016/j.addma.2015.10.001

Quantitative analysis of surface profile in fused deposition modeling

Yu-an Jin[1], Hui Li[2], Yong He[1]*, Jian-zhong Fu[1]

[1]The State Key Lab of Fluid Power Transmission and Control, School of Mechanical Engineering, Zhejiang University, Hangzhou 310027, China

[2]Department of Mechanical Engineering, South China University of Technology, Guangzhou 510641, China

* Correspondence to: Yong He; e-mail: yongqin@zju.edu.cn)

Abstract: Fused deposition modeling (FDM) is a well-know additive manufacturing technique, which can transfer digital three-dimensional (3D) models into functional components directly. Despite many advantages FDM can offer, poor surface accuracy of fabricated objects has always been a big issue that attracts increasing attention. To study the influence on the surface profiles imposed by various process parameters effectively as well as quantitatively, the mathematical model of the surface profile need to be developed. In this work, a new surface profile model is developed to characterize the surface profile of FDM fabricated parts. The process parameters are classified into two groups (i. e. pre-process parameters and fabrication process parameters) to investigate the impacts on surface characterization. Corresponding experiments are conducted using a FDM machine to make comparison with the predicted values and to validate the reliability and effectiveness of the proposed surface models. Both the experimental results and theoretical values indicate that the surface accuracy of the top surface is mainly determined by the ratio between molten paste flowrate and the nozzle feedrate under specified layer thickness and path spacing. On the other hand, the surface quality of the side surface is primarily affected by the layer thickness and the stratification angle of the surface. At the same time, some optimization approaches for the surface improvement are presented: appropriate ratio between paste flowrate and fabrication speed are required for desirable top surface and thinner layer thickness can, to some extent, alleviate the staircase effect out of the slicing procedure and the stratification angle of the side surface should be confined to a range to avoid large geometric errors.

Keywords: Fused deposition modeling; Surface profile; Quantitative characterization; process parameters

1. Introduction

Fused deposition modeling (FDM), one of additive manufacturing (AM) technologies, can fabricate three dimensional (3D) objects from virtual CAD models with complex geometrical shapes, in a relatively fast way to reduce the product development cycle period [1]. Through a layer-upon-layer process along a pre-determined orientation, 3D structures are built approximately by hundreds of planar layers without geometric restrictions [2]. Due to its advantages of low cost, convenient and high material usage efficiency, FDM shows great potential in mould fabrication [3], bio-medical device design [4], tissue engineering [5] and other industrial fields [6-8]. Technically, FDM is essentially a layer-based sequential material deposition process to build functional parts [9]. As shown in Fig.1, the plastic filament is fed into a heated extruder by the motor driving force from a coil reel, and transferred into molten paste to be extruded from the nozzle tip. The extruded material is squeezed on the base plate line by line based on the pre-designed tool-paths to form a surface, and finally a 3D part. After one layer has been completed, the extruder is lifted by a distance of layer thickness to deposit another layer. Although this layer-by-layer process can achieve the fabrication of any complex shapes, there are still some undesirable drawbacks coming with its advantages, including long build time, poor surface finish and mechanical strength.