Faculty of Mechanical and Manufacturing Engineering Technology

INVESTIGATION OF CURLING EFFECT OF 3D-PRINTED ABS STRUCTURE ON DIFFERENT PRINT BED TEMPERATURES AND SURFACES

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Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

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INVESTIGATION OF CURLING EFFECT OF 3D-PRINTED ABS STRUCTURE ON DIFFERENT PRINT BED TEMPERATURES AND SURFACES

CHUNG SEE ERN

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ABSTRACT

One of the problems in Fused Deposition Modelling (FDM) 3D printing process is that the extruded plastic filament tends to curl and deformed from the print bed and sometimes peeled away from the print bed. The purpose of this research is to characterize the curling behaviours and surface roughness of ABS structure fabricated using different print bed temperature and different print bed materials. The current research investigates the specimens produced by 3D printer Flash Forge Creator Pro. The print bed temperature and print bed material were under direct variations in order to examine if there was an influence on geometric shape and surface roughness of 3D printed structures. The test specimen model of dog bone shaped compliant to the ASTM D638-10 standard. A type I specimen profile is adopted. Then the printing process is set at different range of print bed temperature (100,105,110,115,120°C). The print bed conditions is printed on original print bed and on zinc plate with adhesives. Zinc plates was applied onto the print bed to reduce warping deformation and surface roughness. There are three testing carried out. Firstly, the heat flow rate of both print bed is measured using heat flow meter. The zinc plates have lower heat flow rate. Heat flow rate will increase when print bed temperature increased. Secondly, the 3D printed specimens were measured their curling effect using 3D scanner and metrology software. The result shows that the specimens printed on zinc plate has low deformation compared to specimens printed on original print bed. The deformations increased as the print bed temperature increased. Lastly, the surface roughness test by using surface profilometer. The surface parameter is the average mean surface roughness (R_a, µm), the root means square surface roughness (R_q, µm) and the surface roughness depth (R_z, µm). The examination showed conditionally, as temperature was increased the surface roughness print bed temperature were further increased, as the zinc plate and adhesive added, the surface quality increased. The ABS specimen printed on zinc plate with print bed temperature of 100ºC have the least deformations and high surface quality.

ABSTRAK

Salah satu masalah dalam proses pencetakan 3D adalah filamen plastik yang tersemperit akan cenderung untuk "curl" dari katil cetakan dan kadang senang untuk mengelupas dari katil cetakan. Tujuan kajian ini adalah untuk mencirikan masalah "curling" dan kekasaran permukaan struktur ABS yang dicetak menggunakan suhu katil cetakan dan keadaan katil cetakan yang berlainan. Penyelidikan dijalankan dengan mengunakan spesimen yang dihasilkan oleh pencetak 3D Flash Forge Creator Pro. Suhu katil cetakan dan bahan katil cetakan divariasikan untuk mengkaji jika terdapat pengaruh terhadap bentuk geometri dan kekasaran permukaan 3D struktur. Model ujian berbentuk tulang anjing yang mematuhi "standard ASTM D638-10" digunakan. Profil jenis spesimen I digunakan. Kemudian proses pencetakan dengan suhu katil cetakan yang berlainan dijalankan (100,105,110,115,120 ° C). Keadaan katil cetakan ialan katil cetakan asal dan plat zink dengan pelekat. Plat zink digunakan untuk mengurangkan "curling" dan kekasaran permukaan struktur. Terdapat tiga ujian dijalankan. Pertama, kadar aliran haba bagi kedua-dua keadaan katil cetakan diukur menggunakan meter aliran haba. Plat zink mempunyai kadar aliran haba yang lebih rendah. Kadar aliran haba akan meningkat apabila suhu katil cetak meningkat. Kedua, spesimen diukur kesan "curling" mereka menggunakan perisian pemindai 3D dan aplikasi metrologi. Hasilnya menunjukkan bahawa spesimen yang dicetak pada plat zink mempunyai kesan "curling" yang rendah berbanding spesimen yang dicetak di atas katil cetakan asal. Perubahan bentuk meningkat apabila suhu katil cetak meningkat. Ketiga, ujian kekasaran permukaan menggunakan "surface profilometer". Faktor permukaan ialah kekasaran permukaan purata (Ra, µm), RMS kekasaran permukaan (Rq, µm) dan kedalaman kekasaran permukaan (Rz, µm). Pemeriksaan menunjukkan bahawa kekasaran permukaan semakin meningkat apabila suhu katil cetakan meningkat. Tapi specimen yang dicetak di atas plat zink dengan pelekat mempunyai kualiti permukaan lebih tinggi berbanding dengan katil cetakan asal. Spesimen ABS yang dicetak pada plat zink dengan suhu katil cetakan 100ºC mempunyai kesan "curling" yang lebih kurang dan kualiti permukaan yang lebih tinggi.

DEDICATION

This report is especially dedicated to my parents for their endless love, support and encouragement. And to my lecturer Associate Professor Dr. Lau Kok Tee which have guide me along the way for me to finish this project. Thanks for all your support and give me strength until I finish this project.

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$\mathbf{R_a}$	-	The arithmetic mean surface roughness
$\mathbf{R_q}$	-	RMS of surface roughness
$\mathbf{R_z}$	-	Maximum Height of Surface roughness

LIST OF ABBREVIATIONS

ABS	Acrylonitrile Butadiene Styrene
AM	Additive Manufacturing
CAD	Computer Aided Design
FDM	Fused Deposition Modelling
PLA	Polylactic Acid
PP	Polypropylene
STL	Stereolithography
3D	Three-Dimensional

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter describes the overview of this study. It includes the research background, problem statement, objectives and the scope of project.

1.1 Research Background

3D printing is a technology used to duplicate object, despites its complexity. The 3D printing is also well known as Additive Manufacturing, which means producing a physical object layer by layer additively (Hausman et al., 2014). A virtual computer data file is exported as a stereolithography (STL) file and transfer into a slicer program. The slicing program sliced the STL file into different horizontal layers. Each of the layer have specified layer height and layer thickness according to the parameter setting of slicer program. The information is generated as G-code and built a tool path for extruder to travel. On the other side, the extruder head is heated up to melt the filament materials. The melted filament materials are extruder through the nozzle. The nozzle head travel according to the tool path generated from G-code to print the base layer of the part. After the base layer is printed, the print bed moves one-layer thickness downward in order to build the following layers. The process is repeated until the part is completed within the estimated time given by the slicer software. Finally, the completed part can be taken out of the print bed.

In 3D printing, solidification shrinkage is the main factor contribute to the distortion of shapes from print bed (Kochesfahani, 2016). Shrinkage is defined as a change of length, area or volume of a component without external forces (Schmutzler et al., 2016). Printing parameters such as extrusion head temperature, print bed temperature, extrusion speed and printing speed and process parameter such as layer thickness is the main factor of shrinkage and deformation of geometry shape occurs (Zhu et al., 2017). This study focused curling behaviour and surface roughness of the specimens printed on different print bed temperature and print bed conditions. During the printing process, the filament material is extruded on the print bed. If the temperature of the print bed is lower than the melting temperature of the filament material, the extrudate will be solidified on the surface (Kochesfahani, 2016). In this case, the temperature settings for the print bed and the ambient temperature will affect the shape geometry.

Surface roughness is a surface component that can be measured with deviations in the normal direction of an actual surface (Kovan et al., 2018). When the deviation is significant, the printed part's surface is considered as rough. When the deviations is small, the printed part's surface is considered as smooth. Surfaces roughness determines the performance and functionality of the part. The surface roughness of 3D printed part is affected by layer thickness and print speed. As the layer thickness decreases, lower surface roughness values are obtained (Kovan et al., 2018). In this study, the relationship between the print bed conditions and surface roughness is investigated.