UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DETERMINATION OF THE INFLUENCE OF CHEMICAL TREATMENT TO THE STRENGTH OF FDM USED PART

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Design) with Honours.

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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SESI PENGAJIAN: **2015/16 Semester 2**

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I hereby, declared this report entitled “Determination Of The Influence of Chemical Treatment To The Strength Of FDM Used Part” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The member of the supervisory is as follow:

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Pn Ruzy Haryati Binti Hambali

(Project Supervisor)

ABSTRAK

Additve Manufacturing (AM) merupakan proses penggabungan bahan untuk mencipta objek daripada model CAD secara berlapis-lapis. Fused Deposition Modeling adalah antara teknologi penyemperitan untuk membentuk produk- produk. Teknologi FDM telah digunakan dalam pelbagai industri, seperti pembuatan produk-produk pengguna. Namun, FDM mempunyai kualiti permukaan yang tidak memuaskan disebabkan kesan "staircase" dan proses-proses penambaikan permukaan diperlukan. Bagi menghasilkan permukaan yang lebih licin, L.M Galantucci (2009) menyatakan bahawa rawatan kimia adalah salah satu kaedah yang baik dan cepat untuk meningkatkan kemasan permukaan ABS yang dimodelkan daripada mesin FDM melalui mencelup dan merendam produk tersebut dalam larutan acetone. Dengan itu, kajian ini bertujuan untuk mengkaji pengaruh rawatan kimia terhadap kualiti permukaan dan kekuatan produk FDM. Dalam projek ini, sepuluh specimen dogbone dengan klip akan difabrikasi dengan mesin cetak 3D MOJO. Hasilnya, dogbone yang dirawat kimia telah bertambah baik secara mendadak dari segi kekasaran permukaan berbanding dogbone yang tidak dirawat, peningkatan 97.2%. Klip dirawat juga menunjukkan secara drastik bertambah baik dari segi kemasan permukaan berbanding dengan klip tidak dirawat, peningkatan 96.12%. Namun, kekuatan tegangan bahagian dikurangkan 42.58% disebabkan oleh kesan penggabungan filament. Finite Element Analysis (FEA) digunakan untuk mengesahkan data yang diperolehi. Jadi, rawatan kimia adalah satu pendekatan ekonomi dan mampan untuk meningkatkan kualiti permukaan bahagian Additive Manufacturing.

ABSTRACT

Additive Manufacturing (AM) is the process of joining materials to create objects from the CAD model via layer upon layer. One of the common technologies of Additive Manufacturing is Fused Deposition Modeling (FDM), which uses extrusion to form parts. FDM technology has been applied in many applications such as consumer product manufacturing as well as end-used parts. However, FDM suffers badly from low surface quality due to the staircase effect and post treatment is required. In order to yield significant improvement of the surface roughness, L.M Galantucci (2009) stated that chemical treatment is one of the economic and fast method to enhance surface finish ABS (Acrylonitrile- Butadiene-Styrene) fused modeled part by performing chemical treatment in a acetone solution. Therefore, this research aims to investigate the influence of chemical treatment on the FDM used part in terms of surface roughness as well as strength. In this project, ten specimens of standard ASTM D638 dogbone specimen and clips will be fabricated using MOJO 3D Printer. As a result, the chemically treated dogbone has dramatically improved in term of surface roughness compared to the untreated dogbone with 97.2% improvement. The treated clips show significantly improved in term of surface finish compared to the untreated clips by 96.12% improvement. However, the tensile strength of the dogbone is reduced 42.58% due to the joining effects of filaments. Finite Element Analysis (FEA) is used to validate the data obtained. In a nutshell, chemical treatment is an economic and sustainable approach to enhance the surface quality of Additive Manufacturing parts.

DEDICATION

To my beloved family member
my beloved father, Cheong Kooi Seong
my appreciated mother, Low Chew Hon
and my adored sister Cheong Chui Yee
for giving me moral support, cooperation, encouragement and also understanding
along this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	-	Acrylonitrile butadiene styrene
AM	-	Additive manufacturing
ASTM	-	American Society for Testing and Materials
C_3H_3N	-	Acrylonitrile
C_4H_6	-	Butadiene
C_8H_8	-	Styrene
CAD	-	Computer-aided Design
CNC	-	Computer Numerical Control
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
FDM	-	Fused Deposition Modelling
FTMK	-	Fakulti Teknologi Maklumat dan Komunikasi
STL	-	Stereolithography
UTeM	-	Universiti Teknikal Malaysia Melaka
2D	-	2 Dimension
3D	-	3 Dimension
σ	-	Tensile stress

CHAPTER 1

INTRODUCTION

This chapter basically discusses the project's background based on the Additive Manufacturing and Fused Deposition Modeling (FDM). The problem statement, objectives and scopes will also be explained in this chapter. Project planning and execution of this project will also include in this chapter.

1.1 Project Background

Additive Manufacturing (AM) is a group of techniques used to fabricate quickly a scaled model of a physical part using a CAD system. It describes the technology of generative production processes. According to ASTM definition, Additive Manufacturing is the process of joining materials to create objects from the CAD model by layer upon layer. One of the common technologies of AM is Fused Deposition Modeling (FDM). FDM is a solid-based additive manufacturing system that utilizes solids as the primary medium to create parts, which uses extrusion to form parts (Gibson, 2010). FDM can be considered as additive manufacturing by laying down material in layers that use Acrylonitrile- Butadiene-Styrene (ABS) in the form of plastic filament using molten material system (Gibson, 2010). Since FDM works on an additive principle by laying down material in layers, the modeled part is produced by extruding small beads of thermoplastic material to form layers as

the material solidified extrusion from nozzle since the platform is maintained at a lower temperature.

Some advantages of the FDM modeled part are good in strength, heat and resistance and suitable for many applications such as aerospace and medical application. However, this FDM suffers poorly from low surface quality and postulating post-finishing process due to the fabrication process which prescribed by the filament thickness (L.M Galantucci, 2009).

Furthermore, FDM technology has expanded not only to be used as a prototype, but as well as functional applications as the end-used parts. Therefore, the strength and surface finish of the FDM part are important considerations to assure the quality and usability of the FDM end-used product with satisfactory physical and mechanical qualities.

In order to attain a good surface finish, researches had been done to recognize the parameters which can give obvious effect to the surface roughness of the parts produced include built orientation, slicing height and chemical treatment (Gurpal and Parlad, 2014). In this report, the parameter that will be discussed in detail is chemical treatment. It is used to enhance the surface finish of ABS fused modeled part by chemical dipping that yielding significant improvement of the roughness of the treated specimen (L.M. Galantucci, 2009). Although the implementation of the chemical treatment on the FDM part will gives effect on the tensile strength of the part, the proposed chemical post treatment will be fast, ecomomic and easy to be conducted method to improve the surface finish of the ABS parts.

To fully exploit this potential, an experimental analysis should be done to determine the influence of chemical treatment to the FDM part. This project is dedicated to the study of the ABS material, the fabrication process of FDM, physical and mechanical

behavior of the FDM parts. Theoretical and experimental analysis will be carried out to determine the influence of the chemical treatment to the strength of the FDM end-used parts. To validate the data obtained, simulation of Finite Element Analysis (FEA) using Solidwork is applied.

1.2 Problem Statement

Nowadays, Fused Deposition Modeling parts has not only be used as testing prototype but also an used as end-used part in different industry such as consumer products and medical application. Hence, the FDM fabricated part should obtains good surface finish with sufficient strength part. From the literature reviews, researches have reported to address the problem faced by the FDM parts and having difficulty in improving the surface properties and mechanical properties of FDM parts. L.M Galantucci (2009) categorized some approaches in enhancing surface roughness of AM parts into four main parameters, such as (i) optimal builds direction, (ii) slicing strategy, (iii) fabrication parameters optimization and (iv) horizontal surface. Besides, chemical treatment is introduced by L.M Galantucci (2009) to improve the surface roughness of the FDM parts of ABS material (L.M Galantucci et. al, 2009). However, it had reported this treatment may affect the tensile strength of the FDM parts. Zinniel (2008) had stated that there is an ongoing need for the surface treatment techniques that provide an aesthetically pleasing surface of the Rapid Manufactured AM parts. Hence, an experimental study is essential in order to determine the influence of chemical treatment on the strength of the FDM parts.

Besides, as reported by Espalin D. Media (2009), LM Galantucci (2009) and LM Galantucci (2010) depicted that the chemical surface treatment method performs better if compared to other methods and agreed that chemical treatment needs marginal human intervention, easy and low cost method.

Therefore, this research focuses on the chemical surface treatment method to eliminate the irregularities on the surface of parts produced via FDM by chemical smoothing reaction observed the improvement of the finishing as well as the behaviour of the finishing. This led in investigating the effect of the chemical treatment to the FDM parts on surface quality and mechanical strength as well maintaining the original dimension without degrading the quality of the parts. Further simulation will take place to validate all the data obtained using FEA results and compared with the experimental data.

1.3 Objectives

The aim of this project is to investigate the influence of chemical treatment to the FDM end- used part. The objectives of this project are as follows:

1. To design and fabricate end-used parts using Fused Deposition Modeling.
2. To determine the influence of chemical treatment to the physical and mechanical properties of FDM used part.
3. To validate the data via Finite Element Analysis (FEA) using Solidwork Simulation.

1.4 Scope of Project

This project mainly focuses on Additive Manufacturing technology of Fused Deposition Modeling (FDM) in the fabrication of the test model and the end-used parts. The analysis on the influence of chemical treatment on the surface roughness as well as the strength of the part will be included in this project. The interrelation between the surface roughness and the strength of the chemically-treated part will be investigated. The FEA analysis will be performed to validate the result obtained.

Mass production and marketing of the proposed end-used parts are not included in this project.

1.5 Project Planning and Execution

In this project, the Gantt chart is constructed to list all the related task and possible time to finish respective task from the start of the project until report submission. This project schedule is presented in Appendix A.

CHAPTER 2

LITERATURE REVIEW

This chapter began with various definitions and terminologies of Rapid Manufacturing (RM) and Additive Manufacturing (AM). Basic principles and important concepts of additive manufacturing as well as classification of Additive Manufacturing technologies are explained in this chapter. Details regarding Fused Deposition Modeling (FDM) will be covered in this chapter. Related research will also include in this chapter.

2.1 Overview of Additive Manufacturing

In past few years, market importance for Additive Manufacturing becoming greater when the research on industrial applications conducted worldwide. AM applications are currently across many various sectors such as automotive, consumer product manufacturing as well as the production of medical apparatus (Wohlers, 2011). Nowadays these techniques not only used to produce prototypes or models as well as functional parts in respective industries. Therefore, the demand for high level