UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY THE INFLUENCE OF ACETONE TO IMPROVE SURFACE FINISH OF 3D PRINTED PART FOR ABS AND PLA MATERIAL

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

by

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DECLARATION

I hereby, declared this report entitled "Study the Influence of Acetone to Improve Surface Finish of 3D Printed Part for ABS and PLA Material" is the result of my own research except as cited in the 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 committee is followed:

……

(Official Stamp of Supervisor)

ABSTRAK

Additive Manufacturing (AM) ditakrifkan mengikut ASTM ialah proses penggabungan bahan untuk mencipta objek daripada model CAD secara berlapis-lapis. *Fused Deposited Modelling* (FDM) adalah antara teknologi penyemperitan untuk membentuk produk-produk. Namun, FDM mempunyai kualiti permukaan yang tidak memuaskan disebabkan kesan "staircase" dan proses-proses penambaikan permukaan diperlukan. Bagi menghasilkan permukaan yang lebih licin, 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. Dalam projek ini, 16 spesimen kiub dengan berukuran 20mm X 20mm X 20mm ABS dan PLA telah direka menggunakan UP Plus 2D Printer. Data eksperimen telah diambil daripada peratusan yang berbeza bagi Acetone yang ditambah dengan air dan perbezaan Aceton tersebut ialah sebanyak 85%, 90%, 95% dan 100%. Hasilnya, produk telah tenggelam dalam peratusan yang berbeza menunjukkan keputusan yang berbeza bacaan kekasaran permukaan oleh ABS dan PLA . Rawatan kimia yang dirawat produk ABS menunjukkan keputusan secara mendadak jatuh bacaan permukaan spesimen. Ia boleh membuat kesimpulan bahawa bahan ABS yang mempunyai rintangan kimia yang rendah untuk larut dalam mandi kimia bagi meningkatkan kemasan permukaan. Tetapi, bagi PLA hasilnya menunjukkan apabila menggunakan peratusan yang lebih tinggi Aceton, tingkah laku permukaan menjadi lebih teruk dan membuat ia menjadi pudar kerana tindak balas kimia. Secara ringkas, rawatan kimia adalah satu pendekatan yang berkesan untuk meningkatkan kualiti permukaan AM.

ABSTRACT

Additive Manufacturing (AM) is defined as according to ASTM is a process joining materials to create objects from 3D CAD model via layer upon layer. One of the common technology of AM is Fused Deposited Modelling (FDM), which uses the method of 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 finish quality due to staircase effect and post treatment is required. In order to yield significant improvement of the surface roughness, the chemical treatment is one economic and fast method to enhance surface finish of ABS (Acrylonitrile Butadiene Stryene) fused modeled part by performing chemical treatment in Acetone solution. Therefore, this research aims to investigate the influence of chemical treatment on the FDM used parts in term of surface roughness. In this project, the 16 specimens of the cube with the dimension 20mm X 20mm X 20mm of ABS and PLA were fabricated using UP Plus 2D printer. The experiment data were taken of different percentage of Acetone added with water of 85%, 90%, 95% and 100% of Acetone As a result, the specimens were immersed in different percentage shows the different result of surface roughness reading by ABS and PLA. The chemical treatment that treated the specimens of ABS shows the result dramatically drop the surface reading of the specimens. It can be concluded that the ABS material has a low chemical resistance in order to dissolve in the chemical bath for improving the surface finish. But, for the PLA the result shows when use the higher the percentage of Acetone, the surface behavior becomes worse and make it pale due the chemical reaction. In a nutshell, the chemical treatment is a sustainable approach to enhance the surface quality of AM.

DEDICATION

To my beloved family member
My beloved father, Ishak Md Saad
My appreciated mother, Salmah Binti Ismail
My adored sister Nadia Binti Ishak
and my fellow friends from 4BMFR
for giving me moral support, money, cooperation, encouragement and also understanding along this project.

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I hope that this project will fulfil the condition as requested in Final Year Project in UteM. Thank you.

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LIST OF ABBREVIATION

ASTM	-	American Society for Testing and Materials
SOP	-	Standard Operation Procedure
PLA	-	Polylactic Acid
ABS	-	Acrylonitrile Butadiene Styrene
3D	-	3 Dimensional
CAD	-	Computer Aided Design
AM	-	Additive Manufacturing
FDM	-	Fused Deposition Modelling
SLS	-	Selective Laser Sintering
SLA	-	Stereolothography
SAN	-	Styrene Acrylonitrile Copolymer
ROP	-	Ring Open Polymerization

LIST OF SYMBOLS

Min	-	Minutes
mm/s	-	Millimeters per seconds
℃	-	Degree Celcius
MPa	-	Mega Pascal
GPa	-	Giga Pascal

CHAPTER 1
INTRODUCTION

This chapter presents of general idea of the research of the project which provide an overview of background of study, the problem statement, goal objectives, and the scope of study. From the background of the study, the issue explanation will achieve distinguish of the objective of the study. The sole of this project is to understand the fundamental of additive manufacturing and the problem facing while the product produces using AM also to distinguish the post-processing process by applying different material in order to get the best surface finish.

1.1 Project Background

Additive manufacturing (AM) is a group of technique used to fabricate quickly a scaled model of a physical part using a CAD system. According to (Ian Gibson, David Rosen, Brent Stucker, 2010), the AM works that parts are made by adding material in layers, each layer in thin cross-section of the part derived from the original CAD data. One of the common technologies of AM is used Fused Deposition Modeling (FDM) machine. FDM was developed by S. Scott Crump and marketed exclusively by Strayasys Inc. that FDM can be laying down material in layers that use (PLA and ABS) in form plastic filament or metal wire is unwound from a coil and supplies material to an extrusion nozzle.

The FDM technology not only use for prototyping, but it also function as well application for end-used parts. Due this application, the surface finish need to be considered to get the best quality and usability of FDM end-used product in term of physical and mechanical quality. Since FDM works by laying down material from the bottom-up, which process one layer at a time, the part is produced by heat the nozzle to form a solidified layer of material. Thus, the platform is needed to maintain at lower temperature.

Therefore, in order to attain a good finish, the research about the parameter of surface roughness of part produce had been done. In the literature review, the research was about the effect of surface roughness include the problem in surface finish for 3D printed specimen and post-treatment for printed part (Singh Bual & Kumar, 2014).

In this report, detail about the parameter in post-processing stage that is chemical treatment will be discuss. This because the aim of this project is to increase the surface finish of the part that produce by PLA and ABS material by conducting the experiment about the influence of acetone in printed specimen. This project also will be design the specimen to be print part using 3D printed machine that is UP Plus 2D printer.

1.2 Problem Statement

Nowadays, the application of additive manufacturing was world wide and FDM is the most popular AM process because it faster, economical and clean technology. However, FDM suffers from low surface finish quality and each machine of FDM have their problem face on the surface finish. For this project, the research about surface finish which using FDM machine should be obtain good surface finish with sufficient strength part. From the researches have reported that the problem faced by FDM parts and having difficulty in improving the surface properties of FDM parts. From (Alastair Jennings, 2016) state that there have several problems and troubleshooting that had found in 3D printing. The problem or troubleshooting that usually occurs in 3D printing were consists of warping, stringing, layer misalignment and missing layer. These problems had caused the surface finish of the part becomes rough and not good looking also not good in

mechanical properties that may affect the quality of physical and mechanical strength properties.

In addition, the research from (Singh Bual & Kumar, 2014) stated that there have some method in enhancing surface finish that can be divide into four main parameters that include of (i) optimization of build orientation, (ii) slicing strategy on layer thickness, (iii) fabrication parameters optimization and (iv) post-treatment. By using the post treatment technique, it can be observe of influence the chemical treatment in post processing stage in order to get a good surface finish.

Therefore, in order to investigate the chemical treatment method in post-processing process that produce using FDM machine by applying the different material would be seen the result after experiment done. In other hand, observation of influence the acetone with different range of percentage through different time will be recorded in order to compare the result from the previous study.

The 1.3 Objective

The purpose of this project is to investigate the problem face in surface finish to FDM end-used part. The objective of this project is as follows:

1. To perform a work study on the problem in surface finish for 3D printed specimens
2. To design and print the part using the 3D printer machine.
3. To investigate the influence of acetone in surface treatment of 3D printed specimens.

1.4 Scope and Limitation of Project

This project mainly focuses on Additive Manufacturing (AM) by using technology of Fused Deposition Modeling (FDM) in fabrication of test specimen parts. This project will study about the literature review of problem in surface finish for 3D printed specimen. The test will use the same design specimen for applying on different material. The test also

will compare the surface roughness analysis on the result of different time and percentage acetone and water. The percentage of Acetone used to conduct this project are 85%, 90%, 95% and 100%. The limitation of this project has used the same printer machine for ABS and PLA material.

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 will discuss about the previous research on problem face in surface finish and improvement the surface finish of Fused Deposition Modelling (FDM) parts. This chapter began with a definition of Additive Manufacturing (AM) and important concepts of AM. Detail regarding of problem face will be covered in this chapter. Related research will also include in this chapter.

2.1 Definitions of Additive Manufacturing (AM)

Additive Manufacturing become high demand from customer according to new market in realities need faster product development due to global competition (Kuo & Su, 2013). The AM application have use in many various sector and industries such as medical, automotive and consumer product to describe a process for rapidly creating a system or part representation before final release or commercialization. According to (Ian Gibson, David Rosen, Brent Stucker, 2010) the basic principle of AM technologies is that model initially generated using a three-dimensional Computer-Aided Design (3D CAD) system and can be fabricated directly without process planning. In addition, the AM technology also can be producing complex 3D object directly from CAD data.

In generally, Additive Manufacturing (AM) is defined as the process of joining material to make object from 3D CAD data which usually layer upon layer using AM machine. It take a process from computer-aided design (CAD) file and converted to stereolithography (STL) file. The AM technology allow for creation of printed parts and it

also can reduce time and cost product development cycle (Wong & Hernandez, 2012). It also possibility to create a complex shape that difficult to machine and according to Wohler's report 2011 the Figure 2.1 shows that the growth of rapid prototyping rate for 2010 was 24.1%.

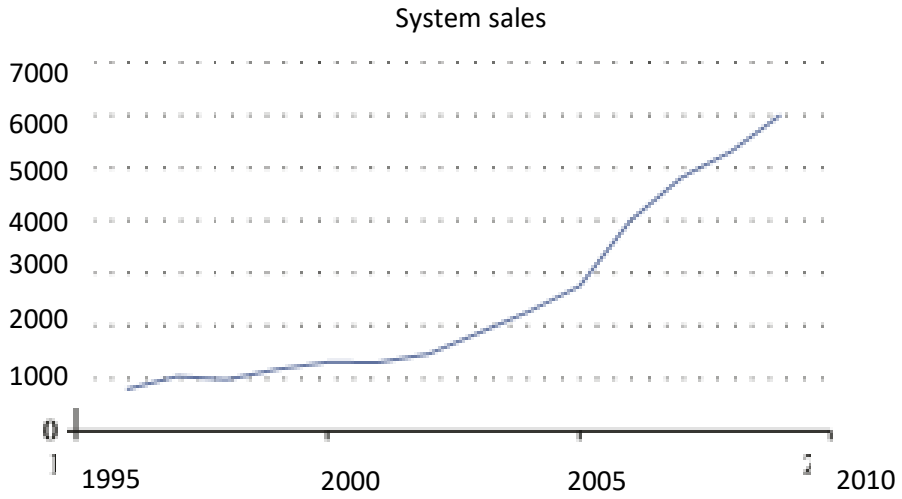

Figure 2.1: Growth of rapid prototyping (Wong & Hernandez, 2012).

Additive manufacturing technology are become important when the design complexity of parts increase by market competitive. Thus, in order to fulfill customer identification, the product development was involved in AM to create model faster hence may save a lot of time and possibility to test more models (Chee Kai Chua, 2003). The process of product development cycle was involved as shown in Figure 2.2.

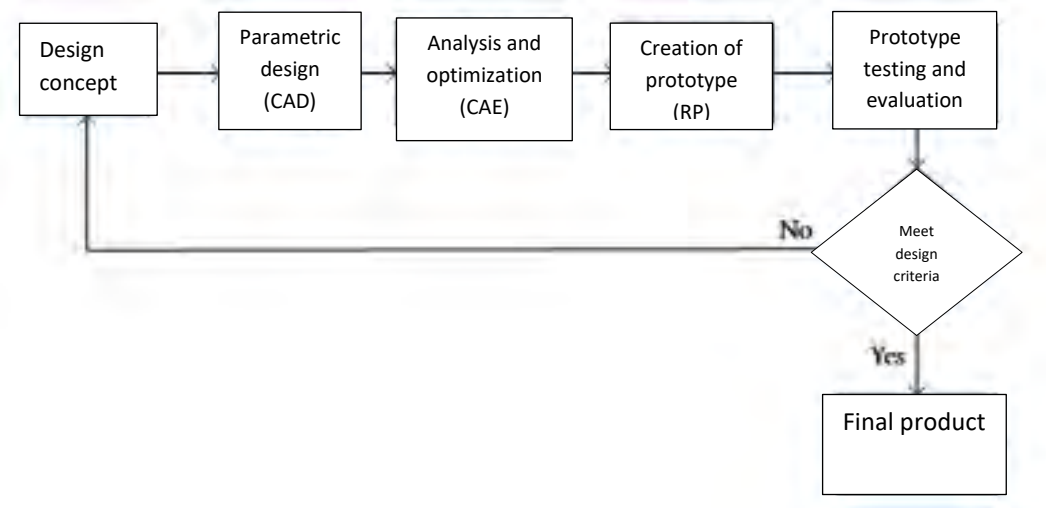

Figure 2.2: Product development cycle (Chee Kai Chua, 2003)

In addition, in AM it had some basic approach that be applied to manufacture. The approach the had been used was process chain that has five steps in the chain and these are 3D modelling, data conservation and transmission, checking and preparing, building and post processing as shown in Figure 2.3.

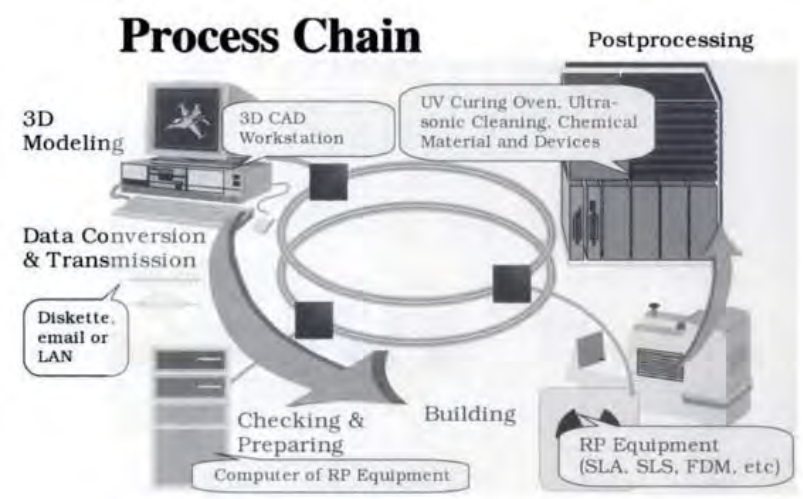

Figure 2.3: Process Chain of Additive Manufacturing process (Chee Kai Chua, 2003).

From the figure above, the fabrication process begins with creating 3D CAD models and transfer to STL file to be manufactured. Then, the STL file is used as input for slicing software into thickness layer and translated the data in standard data format. After that the part is being built with AM system and deposited layer by layer on AM system platform. The post processing is started when the part was finished printed by AM machine with used to clean and remove the support material from the part. Sometimes, the part also need to be polishing, painting and chemical treatment for get the smoother surface finish. Lastly, the part used to be tested and verify that can be used or not.

2.1.1 History of additive manufacturing

At the first phase of prototyping, development manual prototyping which uses craft based prototype is applied. According to (Wohlers & Gornet, 2014) state that the first emerged of AM is Stereolithography (SL) in 1987. From 3D system, a process that solidifies thin layers of ultraviolet (UV) light sensitive liquid polymer using a laser.

In 1991, from (Wohlers & Gornet, 2014) the three AM technology were commercialized, including Fused Deposited Modelling (FDM), Solid Ground Curing (SGC) and Laminated Object Manufacturing (LOM). FDM extrudes thermoplastic materials in filament form to produce parts layer by layer.

Selective Laser Sintering (SLS) which uses heat from a laser to fuse powder material is available in 1992. In year 1996, first low cost of 3D printer is introduced.Actua 2100 using a technology that deposited wax material layer by layer using inkjet printing mechanism

In year 2000 was a year that full of new generation of Additive Manufacturing introductions. One of the significant generation is Stratasys introduced Prodigy, a machine that fabricated parts in ABS plastic using the FDM technology. (Wohlers & Gornet, 2014)

After year 2000, various Additive Manufacturing Engineering is generated and introduced rapidly due to the demand from the market and rapid improvement of 3D printing technology. For example the Electron Beam Melting are developed in 2007

2.1.2 Development of additive manufacturing

As the first Additive Manufacturing technologies were introduced, manufacturers were aimed to shorten the product development by implementing it in the prototyping stage (Pham, 2003). With the 3D CAD data, the physical models can be generated straightly by AM machines and termed as Rapid Prototyping (RP). The products made by AM machine can be used for assembly testing physically which executed from virtual prototyping (Choi & Chan, 2004)

In this era full of global competition and accelerated product obsolescence in manufacturing industry, RP and raid tooling have emerged as primary key enablers for current rapid manufacturing as a new mode of the product development process for cost saving measure (Hague, Campbell, & Dickens, 2003). Rapid Manufacturing technologies applied to produce end used functional instead of prototypes (Kruth, Leu, & Nakagawa, 1998)