LAYER ADHESION INVESTIGATION OF 3D PRINTER PLATFORM

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Design and Innovation)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2017

DECLARATION

I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged.

Signature : .....
Name : Nornarieyza Binti Rosli
Date : .....

SUPERVISOR DECLARATION

I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for award of the degree of Bachelor of Mechanical Engineering (Design and Innovation).

Signature : .....
Name : Dr Faiz Redza Bin Ramli
Date : .....

DEDICATION

My beloved mother and father

My dearest siblings and fiancé

ABSTRACT

Three-dimensional (3D) printer is a machine used to generate product in 3D drawing using application such as CATIA. This process is also known as additive manufacturing (AM). 3D printer uses heating process to squeeze out melted filament which used to print a product. In printing process, the filament is printed on a platform which applied with certain type of adhesive. This adhesive act as medium to hold the specimen printed. Many type of adhesive had been used in this process which divided into two part which are synthetic and bio adhesive. The use of bio-based adhesive in 3D printing is starting to grow but there are still flaws in the process. In order to overcome this flaws, many research and investigations that can be carry out in order to study in details the problems occur and how to overcome it. One of the highlight problem in this research is warping deformation which occur during printing process on the first layer of specimen. The vertexes of the specimen tend to warp and cause deflection at the side of the specimen. New mixture of plant-based bio adhesive was invented and experimented with the ability of reducing warping deformation while holding the natural friendly criteria of adhesive. In warping deformation, printing using bio based adhesive resulted lower value of vertexes compared to synthetic adhesive. Aside of producing new mixture of plant-based bio adhesive, the viscosity of the adhesive also been investigate in order to ensure that this mixture is suited to be used in 3D printer application. Provided that a new mixture had been done, comparison between the available adhesive which is UHU glue as synthetic adhesive was made in order to identify which adhesive has the strongest criteria of adhesive. This comparison was done by going through tensile test using Universal Tensile Machine Dynamic 8872. From all the result obtained, it is concluded that synthetic adhesive shows the highest strength for tensile test compared to bio adhesive. In overall result, synthetic adhesive is stronger than bio adhesive.

ABSTRAK

Pencetak tiga dimensi (3D) adalah mesin yang digunakan untuk menjana produk dalam lukisan 3D menggunakan aplikasi seperti CATIA. Proses ini juga dikenali sebagai bahan tambahan pembuatan (AM). Pencetak 3D menggunakan proses pemanasan untuk mengeluarkan filamen cair yang digunakan untuk mencetak produk. Dalam proses percetakan, filamen dicetak di atas platform menggunakan jenis pelekat yang tertentu. Tindakan pelekat sebagai medium untuk memegang spesimen yang dicetak. Banyak jenis pelekat telah digunakan dalam proses ini yang dibahagikan kepada dua bahagian iaitu pelekat sintetik dan bio. Penggunaan pelekat berasaskan bio dalam percetakan 3D mula berkembang tetapi masih terdapat kelemahan dalam proses ini. Dalam usaha untuk mengatasi kelemahan, banyak kajian dan penyiasatan yang boleh menjalankan untuk mengkaji dengan terperinci masalah berlaku dan bagaimana untuk mengatasinya. Salah satu masalah kemuncak dalam kajian ini adalah ubah bentuk meleding yang berlaku semasa proses mencetak pada lapisan pertama spesimen. Bucu spesimen cenderung untuk meleding dan menyebabkan pesongan ditepi spesimen. Campuran baru berasaskan tumbuhan pelekat dicipta dan dieksperimen dengan keupayaan untuk mengurangkan ubah bentuk meleding sambil mengekalkan kriteria pelekat yang mesra alam. Dalam ubah bentuk meleding, mencetak menggunakan pelekat berasaskan bio memberikan nilai yang lebih rendah berbanding pelekat sintetik. Selain menghasilkan campuran baru berasaskan tumbuhan bio pelekat, kelikatan pelekat juga telah disiasat untuk memastikan bahawa campuran ini adalah sesuai untuk digunakan dalam penggunaan pencetak 3D. Dengan syarat bahawa campuran baru terjadi itu, perbandingan antara pelekat sedia ada iaitu gam UHU sebagai pelekat sintetik telah dibuat untuk mengenal pasti pelekat mempunyai kriteria pelekat yang kuat. Perbandingan ini dilakukan dengan melalui ujian tegangan menggunakan Universal tegangan Mesin Dynamic 8872. Dari semua keputusan yang diperolehi, dapat disimpulkan bahawa pelekat sintetik menunjukkan kekuatan tertinggi untuk ujian tegangan berbanding pelekat bio. Dalam keputusan keseluruhan, pelekat sintetik adalah lebih kuat berbanding pelekat bio.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and most Merciful.

I am very thankful as I have fulfilled my duty of completing PSM II (Projek Sarjana Muda II) with the help and support by many parties whom have been more than encouraging throughout this project. Firstly, I would like to express my gratitude to my supervisor, Dr. Faiz Redza bin Ramli whom had been a very helpful lecturer with all guidance, support, comment and opinions regarding the project that I had been doing. I also want to thank you for willingly becoming my supervisor for this two semester.

Next, I would like to express my appreciation to my beloved parents, family and fiancé who continuously giving supports in term of money and encouragement during my project. Their concern and consideration for my study is much appreciate as my strongest backbone. Not to forget to all my friends who have been helping in big and small matters and all the motivations given by them. Finally, a big thank you to all other lecturers, technicians, lab assistants and all other peoples whom had been involves in helping me with my project whether in direct or indirect ways.

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LIST OF ABBREVIATIONS

AM	Additive Manufacturing
FFF	Fused Filament Fabrication
ABS	Acrylonitrile-Butadiene-Stryene
PLA	Polylactic Acid
STL	Stereo Lithography
SLA	Stereo Lithography Apparatus
FDM	Fused-Deposition Modeling
CAM	Computer-Aided Manufacturing
LOM	Laminated-Object Manufacturing
SLS	Selective Laser Sintering
DTM	Desk Top Manufacturing
PE	Polyethylene
PEI	Polyetherimide
PC	Polycarbonate
PS	Polystyrene

LIST OF SYMBOL

c	=	Damping coefficient
ξ	=	Damping ratio
F_e	=	Excitation force
E	=	Modulus of elasticity
ε	=	Strain
σ	=	Stress

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

3D printer is also known as additive manufacturing (AM) which used to generated product in three-dimensional using three-dimensional Computer Aided Design software (3D CAD). The product producing process only consists of direct fabrication without any process planning due to the simplification done by the AM technology (Gibson, Rosen, & Stucker, 2010). 3D printing or AM technology nowadays uses a process called fused filament fabrication (FFF). Heated plastic filament squeezed out through a nozzle. This heated filament melt down and from the nozzle, layers by layers part were made with each layer as a thin cross-section. This cross section is derived from the original data produced using CAD. The cooled filament then form a solid object after it fuse together to form strong bond. Producing good three-dimensional product affected by certain characteristics such layer thickness, the material used, bonding process of layers and time taken for each production (Evans, 2012).

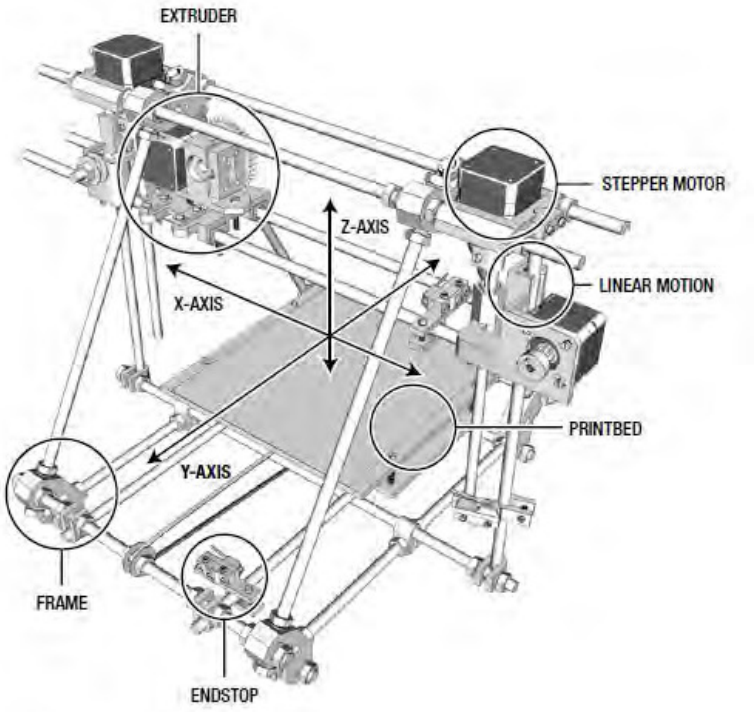

Figure 1.1: 3D printer's parts

Fused Deposition Modelling (FDM) is on the most used extrusion-based from the AM technology. FDM uses filament which was a polymer that been liquidize through a heating chamber. Parts or products produced using FDM are one of the strongest polymer parts due to the range of material used and effective mechanical properties of the parts produced. FDM machine can be used to produce wide range of applications including functional testing models. It operated with different layer of thickness produce from different diameters of nozzle. This nozzle is changeable according the diameter needed for specific build. This machine is widely used and the common material chosen for it process is ABS (acrylonitrile butadiene styrene). According to Stratasys data sheet, apart from using ABS, ABSi, ABSplus and ABS/PC also can be used as side materials due to it characteristics that fulfilling the requirements for FDM machine (Gibson, Rosen, & Stucker, 2010).

In 3D printing process, layer adhesion is the bond between the first layers of product printed with the platform of the printer. Platform or print bed is where the layers of material printed to produce a solid product. Platform need to provide better adhesion in order to avoid or reduce the possibilities of damage to the product. Among problems related to the layer adhesion on platform is warping. Warping is where the underside part of the product bend producing curve corner due to lack of adhesion and also the cooling process happened too quickly. Nowadays, the available solution is by applying glue stick on the platform or covered it with tape. The tape uses mostly made of mixture chemical such as polyimide tape and polyester silicon tape. Other than synthetic adhesive, plant-based bio adhesive also available which more futuristic if 3D printing process will be used in different kind of industry such as printing food using 3D printing in food industry.

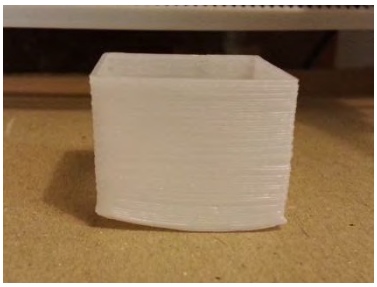

Figure 1.2: Warping

1.2 PROBLEM STATEMENT

The material chosen for the experiment are PLA and ABS. During printing process, those filaments tend to make problems when it is extruded from nozzle. The layers produce tend shrink or producing warping at the underside part. This shrinking and warping will then cause the first layer that should be in contact with the platform to be improperly adhesive to the platform. The curving at the underside will cause the product to be differs than the design

that already been decided and the production process will be a failure. The structure of the product will also be disturbed due to problem with the first layer of product.

Warping is one of the most common problems happen related to the adhesion problem. Warping may occur due to factors like barometric pressure, humidity and temperature. In this project, warping problem is investigated relating to how adhesion on platform will cause it. Mostly, method such as applying tape and synthetic glues is done to ensure that warping does not happen. This method shown that is functional but a more natural friendly material need to be used. Hence, a plant-based bio adhesive will be purpose to replace those synthetic adhesive.

1.3 OBJECTIVE

The objectives of this project are as listed:

1. To produce new mixture of plant-based bio adhesive.
2. To investigate the viscosity characteristics of plant-based bio adhesive in 3d printer application.
3. To make a comparison between the synthetic adhesive and plant-based bio adhesive in 3d printer application.

1.4 SCOPE OF PROJECT

The scopes of this project covers:

1. The type of 3D printer used in this project is low cost 3D printer.
2. Types of materials used for the filament printing testing are ABS and PLA.
3. The strength of the bio adhesive will be measured at the first layer of 3D printer part.

CHAPTER 2

LITERATURE REVIEW

2.1 Rapid Prototyping

Rapid prototyping is one of the modern process used to fabricate prototypes using computer-aided design (CAD) as the base design. This process tends to be choose due to its fabrication process that used lesser time compared to traditional methods. The availability of rapid prototyping is due to the demand of using physical model instead of drawing of design. Rapid prototyping divided into two types which are material removing manufacturing and additive manufacturing or also called three-dimensional printing (Groover, 2010). In general, material removing is where the material cut in order to shape the product. Among the processes involve are drilling and milling whether using conventional or non-conventional machine. In this project, focusing on additive manufacturing, it divided into three prototyping systems which are: -

i. Liquid-Based Rapid Prototyping.
ii. Solid-Based Rapid Prototyping.
iii. Powder-Based Rapid Prototyping.

2.1.1 Liquid-Based Rapid Prototyping

Liquid-based rapid prototyping is one of the rapid prototyping technology which also known as Vat Photo Polymerization. In 1980, Charles (Chuck) Hull discovered that solid polymer patterns could be produced using layer by layer process which give the idea of stereo lithography technology. It is call liquid-based due to the material state that been used in this process which is full liquid without melting solid process. The material that is commonly used is photopolymer. There are few processes that involve in the liquid-based process which have been selected to be focused on: (1) stereo lithography and (2) solid ground curing.

2.1.1.1 Stereo Lithography (STL)

Stereo lithography which also known as STL is a common rapid manufacturing and prototyping technology. STL was discovered around 1986 by the same inventors that had found the liquid-based rapid prototyping technology, Charles W. Hull. This system was first exposed to the world by 3D Systems, Inc around 1988 which has been awarded with international patents. This process had been widely used in liquid-based 3D-printing which involve in the use in ultra violet (UV) light and photopolymer, type of resin to initiate the photopolymerization. Photopolymerization is a process at which resin undergo a chemical reaction to become solid when they were irradiated by UV range of wavelength. Process of