Faculty of Mechanical Engineering

INVESTIGATION OF STARCH ADHESION IN AN OPEN SOURCE 3D PRINTER

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Bachelor in Mechanical Engineering

2018

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A thesis submitted
in fulfilment of the requirements for the degree of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I hereby declare that this project entitled “Investigation of Starch Adhesion in An Open Source 3d Printer” is the results of my own work except as cited in the references.

Signature : ……..

Name : Jerventh Rau A/L Kusraju

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

Signature : …….

Name : Dr. Faiz Redza bin Ramli

Date : …….

ABSTRACT

Three-dimensional (3D) product are normally produced by using a 3D printer by converting 3D drawing from software such as SolidWorks to .stl file. This process is known as additive manufacturing process (AM). Generally, a common 3D printer uses heating element to melt its filament to semi molten and extrude out on a platform, the platform where the filament is printed have adhesive which act as a medium to hold the printed specimen together. Many types of adhesive had been used for this past few years which are synthetic and bio-based adhesive. Bio-based adhesive in 3D printing is starting to grow rapidly but there are still many flaws throughout the process. Many researches can be carried out to study the problems occur in 3D printer, one of the highlighted problems are warping deformation which occur during the first layer of specimen. The specimen vertex tends to warp upwards causing it to peel off from the platform resulting in material, time and energy waste. New mixture of plant-based bio adhesive was studied and experimented to reduce warping deformation at the same time maintaining its environmentally friendly criteria. Besides, viscosity of the adhesive has been tested and analyse to ensure it can be used for 3D printer application. Provided that the mixture has been done, comparison between synthetic and plant-based bio adhesive was carried out by conducting tensile test in order to identify the maximum load it can withstand. From all the data collected, it can be concluded that synthetic adhesive is stronger but plant-based bio adhesive still can be use in 3D printer application as it greatly reduces warping deformation and environmentally friendly.

ABSTRAK

Produk tiga dimensi (3D) biasanya dihasilkan dengan menggunakan pencetak 3D dengan menukar lukisan 3D dari perisian seperti fail SolidWorks ke .stl. Proses ini dikenali sebagai proses bahan tambahan pembuatan (AM). Pada umumnya, pencetak 3D biasa menggunakan proses pemanasan untuk mencairkan filamennya kepada separa lebur dan mencetak pada platform, platform di mana filamen yang dicetak mempunyai pelekat yang bertindak sebagai medium untuk memegang spesimen. Pelbagai jenis pelekat telah digunakan untuk beberapa tahun kebelakangan ini yang terdiri daripada pelekat berasaskan sintetik dan bio. Pelekat berasaskan bio dalam percetakan 3D mula berkembang pesat tetapi masih terdapat banyak kelemahan sepanjang proses. Banyak penyelidikan boleh dijalankan untuk mengkaji masalah yang berlaku dalam pencetak 3D, salah satu masalah kemuncak dalam kajian ini adalah ubah bentuk meleding yang berlaku semasa pencetakan lapisan pertama spesimen. Bucu spesimen cenderung meledingkan ke arah atas menyebabkan ia mengupas dari platform mengakibatkan pembaziran dari segi bahan, masa dan tenaga. Campuran baru pelekat bio berasaskan tumbuhan telah dikaji dan dieksperimen untuk mengurangkan ubah bentuk meleding pada masa yang sama mengekalkan kriteria mesra alam. Selain itu, kelikatan pelekat telah diuji dan dianalisis untuk memastikan ia boleh digunakan untuk aplikasi pencetak 3D. Dengan syarat bahawa campuran baru terjadi itu, perbandingan antara pelekat bio berasaskan sintetik dan tumbuhan dibuat dengan menjalankan ujian tegangan untuk mengenal pasti beban maksimum yang dapat ditahan. Daripada semua keputusan yang diperolehi, dapat disimpulkan bahawa pelekat sintetik lebih kuat tetapi pelekat bio berasaskan tumbuhan masih boleh digunakan dalam aplikasi pencetak 3D kerana ia mengurangkan leding dan juga mesra alam.

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere gratitude to my supervisor Dr Faiz Redza bin Ramli for his invaluable guidance, continuous encouragement and constant support in making this project possible. I really appreciate his guidance from the initial to the final level that enabled me to develop an understanding of this project thoroughly. Without his advice and assistance, it would be a lot tougher to completion. I also sincerely thanks for the time spent proofreading and correcting my mistakes.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I am really thankful for their sacrifice, patience, and understanding that were inevitable to make this work possible. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams.

Lastly, I would like to thanks any person which contributes to my final year project directly or indirectly. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

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LIST OF ABBREVIATIONS

3D	Three-dimensional
ABS	Acrylonitrile Butadiene Styrene
BJ	Binder Jetting
CAD	Computer Aided Drawing
DED	Directed Energy Deposition
DLP	Digital Light Projector
DOD	Drop-On-Demand
EBM	Electron Beam Melting
FDM	Fused Deposition Modeling
FFF	Fused Filament Fabrication
LOM	Laminated Object Manufacturing
PLA	Polylactic Acid
RVA	Rapid Visco Analyser
SFF	Solid Freeform Technique
SGC	Solid Ground Curing
SL	Stereolithography
SLA	Stereo Lithography Apparatus
SLM	Selective Laser Melting
SLS	Selective Laser Sintering

LIST OF SYMBOLS

ε	=	Strain
σ	=	Stress
E	=	Modulus of elasticity

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A process that converts from digital technology to physical object is called Additive Manufacturing (AM) which also refers to 3D printing. 3D printing machine can print objects from a simple to complex design but with limited dimensions. Objects can be of any shape or geometry and typically are delivered using advanced model information from a 3D model. 3D objects are formed by printing thousands of layers from the base to top. Most of the printers nowadays uses Fused Filament Fabrication (FFF) additive manufacturing process where it works by extruding of heated or melted thermoplastic materials through an extrusion nozzle which is then carefully positioned on the bed of the 3D printer forming layer upon layer based on the drawing drawn in the Computer Aided Drawing (CAD) software. The filament most likely will be hardened upon leaving the nozzle which will then fused together forming a strong bond between layers. The final product obtain after printing must be examined properly to avoid product from breaking or damage easily. Layer thickness, materials used and bonding strength between layers should be taken into account in order to produce a good and quality 3D product.

3D printable models can be drawn in Computer Aided Drawing (CAD) software for example Solidworks, Autodesk, and OpenSCAD or obtained by scanning the object using 3D scanner which will then further convert into 3D drawing. 3D printed models created

with CAD result in reduced errors and can be corrected before printing, allowing verification in the design of the object before it is printed (Jacobs, 1992).

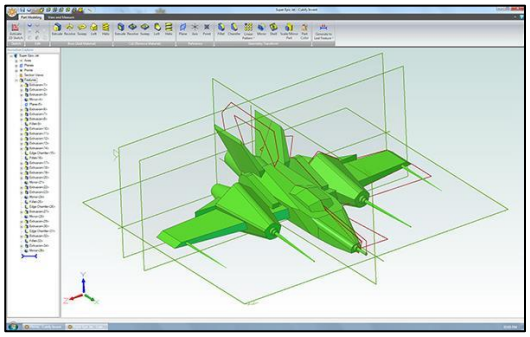

Figure 1.1 CAD model used for 3D printing

The term Additive Manufacturing (AM) holds within such technologies like Rapid Prototyping (RP), Digital Manufacturing (DDM), Layered Manufacturing and 3D printing (Types of 3D printers or 3D printing technologies overview, 2015). There are various types of 3D printing methods that are available in the current market to build 3D structures and objects. Some of them are extremely prevalent these days while others have been ruled by contenders. Below is the Table for the types of 3D printers and its printing method.

Table 1.1 3D printer

3D Printing	Material extrusion	Fused Deposition Modeling (FDM)
	Vat Polymerization	Stereo Lithography Apparatus (SLA) Digital Light Projector (DLP)
	Powder Bed Fusion (Polymers)	Selective Laser Sintering (SLS)
	Material Jetting	Material Jetting Drop-On-Demand
	Binder Jetting	Binder Jetting
	Powder Bed Fusion (Metals)	Selective Laser Melting (SLM) Electron Beam Melting (EBM)

In the process of 3D printing, adhesion plays an important role to ensure the product always remain on the platform or print bed. Platform is a place where materials from the extrusion nozzle is extruded layer by layer to produce a solid product. Therefore, a good adhesion is needed to avoid product from warping, damaging or having uncertain dimensions. Adhesion can be used only if the bottom of the product is flat and smooth surface otherwise the bonding strength between product and the print bed will be weak and causing it glide around the bed while printing (Platform Adhesion, 2018). So, if the base of the product is not even or flat, a skirt will be drawn by the printer. Skirt is a line drawn around the print on the first layer to prime the extruder and also have a good balance on the print bed which will reduce the printing error.

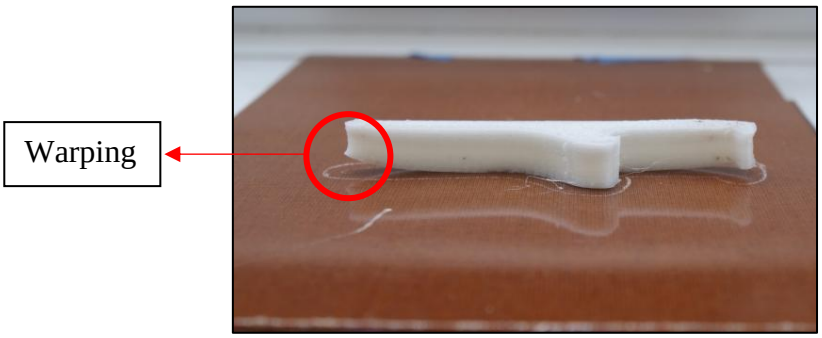

Figure 1.2 Warping

1.2 Problem Statement

Open source 3D printer is an additive manufacturing process that is used to build parts out of plastics and it's replacing conventional method over time. Two materials are chosen for this experiment which are ABS and PLA. Problem occurs when the filament being extruded to the print bed tend to shrink and causes warping at the bottom edge of the product. This is a major drawback for 3D printers when poor adhesives are applied between platform and the first layer of the object thus, it will eventually loss contact or

peel from the platform overtime. This is a common problem among all the 3D printers where ample of time and materials are wasted when the final design differs from the original drawing. Solution to this problem had been solved by using synthetic adhesive or tape but it may cause major impact of globalization on the environment thus an eco-friendlier adhesive is needed to preserve the environment in the future. Hence, plant-based bio adhesive will be the best solution to substitute synthetic adhesives.

1.3 Objectives

The objectives of this project are:

1. To compare warping deformation based on the original design using plant-based adhesive
2. To investigate the new mixture of plant-based bio adhesive using Dioscorea Oppositifolia and Ipomoea Batatas by conducting viscosity test
3. To obtain the maximum load of plant-based bio adhesives by conducting tensile test experiment

1.4 Scope of Project

The scope of this project covers the type of 3D printers where a low-cost 3D printer is used. 2 types of materials, ABS and PLA are used for the filament printing testing using 3D printer throughout the entire project. Furthermore, the strength of the bio adhesives is measured at the first layer of 3D print product.

1.5 Content Overview

In chapter one, student will describe about the problem statement, objectives of the project and the scope of study. In chapter two, it will be more focus on literature review. For chapter three, discussion about the methods to use during the project to solve the problem. Chapter four will cover the result, analysis and the discussion. Finally, the chapter five will be the conclusion for the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Rapid Prototyping

Rapid prototyping is a general term which depicts an assortment of frameworks that can build three dimensional models directly from electronic data. This innovation, first created in the mid 1980's, is based on the solid modeling portion of computer-aided design, or CAD. Solid modeling uses CAD information to completely portray the parts general shape, as well as it's inside volume and outside surfaces.

Rapid prototyping system uses this information to build fabrications layer by layer in thin cross sections. Each layer is stacked upon a past layer until the point that the model is finished. Rapid prototyping construct complex shapes substantially speedier and more essentially than by customary modeling methods. Moreover, these systems can also produce models from data generated from the 3-dimensional digitizing of existing parts, and medical imaging devices (Pham & Dimov, 2001).

Materials used to fabricate prototype models are commonly classified as either liquid, powder, filament, or foil such as thermoplastics, metal powders, photopolymers and ceramic powders (Crow, 2016). Prototyping systems normally work untended, and upon completion, the models can require some post-processing. These post-processing process includes surface finishing and support removal.

Rapid prototyping divided into two main types which are material removing manufacturing and additive manufacturing (Groover, 2010). In general, material removing manufacturing process works in which cutting tools removes unwanted material from a workpiece to form a desired shape of the product using milling or drilling process. Usually, the workpiece will be in a larger piece of stock and various shape. In this project, focusing on additive manufacturing process which are divided into three main prototyping systems which are:

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

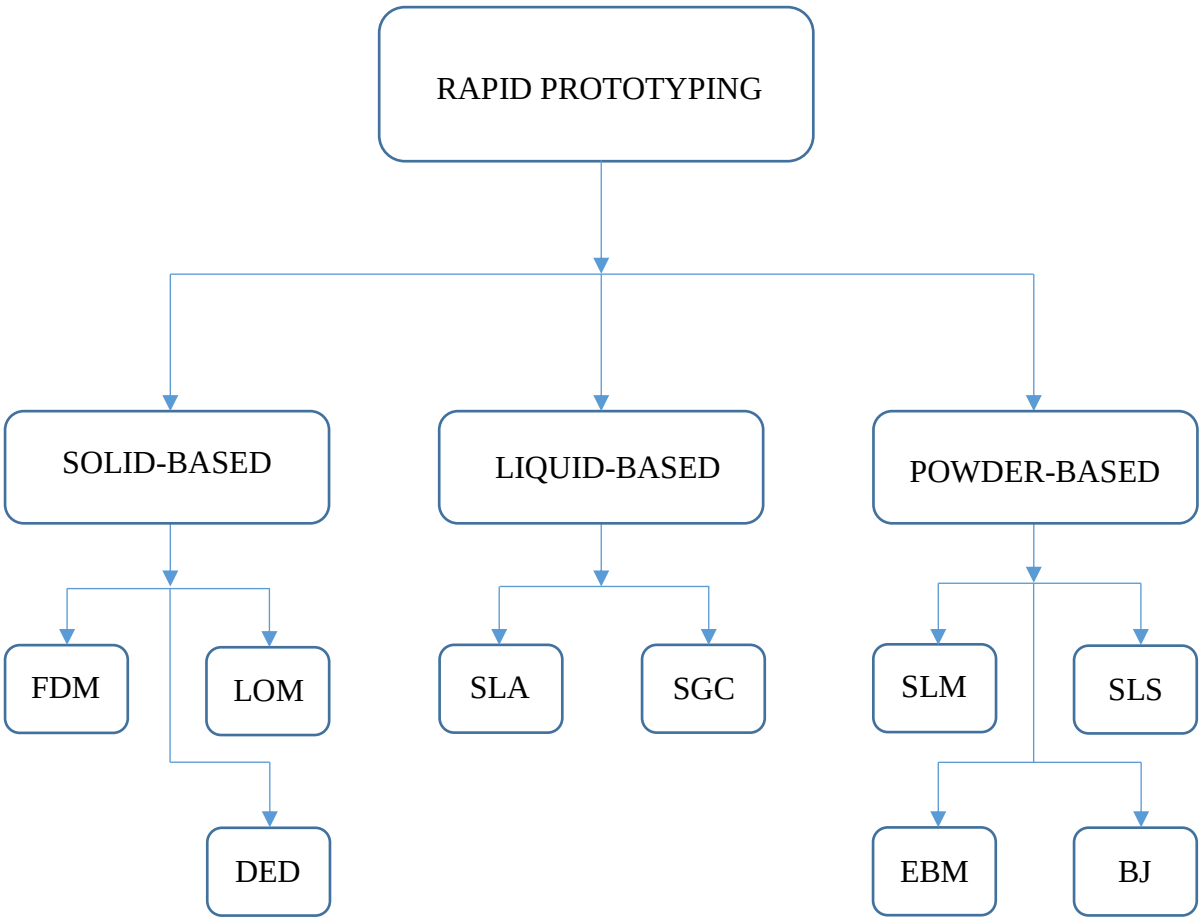

Figure 2.1 Flow chart of rapid prototyping