Faculty of Mechanical and Manufacturing Technology

DEVELOPMENT OF NEW FILAMENT WIRE FROM SUGARCANE BAGASSE FIBRE REINFORCED THERMOPLASTIC COMPOSITES AS FEED STOCK FOR FUSED DEPOSITION MODELLING (FDM) USING EXTRUSION PROCESS

Nur Shazwanie Binti Rashid

Bachelor's Degree in Manufacturing Engineering Technology (Product Design) with Honours

2018

DEVELOPMENT OF NEW FILAMENT WIRE FROM SUGARCANE BAGASSE FIBRE REINFORCED THERMOPLASTIC COMPOSITES AS FEED STOCK FOR FUSED DEPOSITION MODELLING (FDM) USING EXTRUSION PROCESS

NUR SHAZWANIE BINTI RASHID

A thesis submitted in fulfilment of the requirements for the degree of Bachelor's Degree in Manufacturing Engineering Technology (Product Design) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development Of New Filament Wire From Sugarcane Bagasse Fibre Reinforced Thermoplastic Composites As Feed Stock For Fused Deposition Modelling (Fdm) Using Extrusion Process**

SESI PENGAJIAN: **2018/2019**

Saya **NUR SHAZWANIE BINTI RASHID**

Mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Silatandakan (✓)

SULIT	(Mengandungimaklumat yang berdarjahkeselamatanataukepentingan Malaysia sebagaimana yang termaktubdalam AKTA RAHSIA RASMI 1972)
TERHAD	(Mengandungimaklumat TERHAD yang telahditentukanolehorganisasi/badan di manapenyelidikandijalankan)
TIDAK TERHAD	

Disahkan oleh:

Alamat Tetap:

KM 8, Jalan Endau,

Kampung Tenglu,

86800 Mersing, Johor

Cop Rasmi:

Tarikh:______________________________

Tarikh: __________________________

**JikaLaporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD

DECLARATION

I declare this thesis entitle “Development of New Filament Wire from Sugarcane Bagasse Fibre Reinforced Thermoplastic Composites as Feed Stock for Fused Deposition Modelling (FDM) using Extrusion Process” is the result of my own research except as cited in references. The thesis has not been accepted for any degree is not concurrently submitted in candidature of any other degree.

Signature	:	……………………….......................
Name	:	NUR SHAZWANIE BINTI RASHID
Date	:	……………………………………….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor's Degree Manufacturing Engineering Technology (Product Design) with Honours.

Signature	:	…………………………………….
Supervisor Name	:	TS. MOHD NAZRI BIN AHMAD
Date	:	…………………………………….

DEDICATION

First of all, I would like to express my gratitude to Allah S.W.T. for His blessing and guidance. He's the One who fulfil my invocation. Alhamdulillah, then I would like to dedicate my thesis to my family, especially my mother, Mdm. Haslindawati binti Abdul Kadir, who always support and give advices for me. Their endless love, encouragement and supplication are the most important things happened in my life. In addition, I would like to dedicate this work to my project supervisor, Ts. Mohd Nazri bin Ahmad. He had given a lot of guidance, encouragement, assistance and support to me in completing this project. Lastly, I would like to dedicate my thesis to all my lecturers, assistance engineers and friends who gives me support and guidance in any situation.

ABSTRACT

Fused Deposition Modelling (FDM) is a process in 3D printing technology in producing thermoplastic product by heating the wire filament and builds the part layer by layer. Nowadays, natural fibre is getting popular among researcher to use it in thermoplastic composite either as filler or to reinforce the composite. In this study, sugarcane bagasse is chosen fibre to reinforce Polylactic Acid (PLA) composite to develop a wire filament for FDM. This wire filament developed through extrusion process at the same time, the parameter of the extrusion machine need to analyse. Before the experiment started, the materials were dividing into four ratios. In order to developed the wire filament, some processes such as alkalinised, dried and blending process need to emphasize. Not only that, to determine the appropriate temperature used in extrusion process, the materials through a test named rheology and from there, the viscosity of the material observed to ensure the wire filament in correct viscosity. Based on the rheology results, the optimum temperature for this material is 175 °C. Then, this temperature was used as the reference for the extrusion process.

ABSTRAK

Pemodelan Penyatuan Pemendapan (FDM) adalah proses dalam teknologi percetakan 3D dalam menghasilkan produk termoplastik dengan memanaskan wayar filamen dan membina lapisan demi lapisan. Pada masa kini, serat semulajadi semakin popular di kalangan penyelidik untuk menggunakannya dalam komposit termoplastik sama ada sebagai pengisi atau untuk mengukuhkan komposit. Dalam kajian ini, serat tebu dipilih untuk mengukuhkan komposit Asid Polilaktik (PLA) untuk menghasilkan wayar filamen untuk FDM. Wayar filamen ini dihasilkan melalui proses penyemperitan pada masa yang sama, parameter mesin penyemperitan perlu dianalisis. Sebelum eksperimen bermula, bahan-bahan perlu dibahagikan kepada empat bahagian. Untuk menghasilakan wayar filamen, beberapa proses seperti proses alkalinis, penegeringan dan kisar perlu ditekankan. Bukan itu sahaja, untuk menentukan suhu yang sesuai untuk digunakan dalam proses penyemperitan, bahan akan melalui ujian bernama reologi dan dari situ, kelikatan bahan akan diperhatikan untuk memastikan kelikatan wayar filamen dalam kelikatan yang betul. Berdasarkan keputusan reologi, suhu yang optimum ialah 175 ̊C. Setreusnya, suhu ini digunakan sebagai rujukan dalam proses penyemperitan.

ACKNOWLEDGEMENT

Firstly, I would like to express my gratitude to my family, especially my mother, Mdm. Haslindawati binti Abdul Kadir, who always support and give advices for me. The blessing and assistance from them bring me a long way in the journey of life on which I am to embark. Besides that, I would like to express my appreciation to my project supervisor, Ts. Mohd Nazri bin Ahmad. All he had done to assist me will be remembered forever. And then, I would like to express my gratitude to my academic supervisor, Mr. Mazran bin Ahmad for his useful information and support which helped me in completing this task through various stages. Finally, I would like to thanks to all my lecturers, assistance engineers and friends who gives me support and guidance in any situation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

FDM	-	Fused Deposition Modelling
SCBRP	-	Sugarcane bagasse reinforced plastic
PLA	-	Polylactic Acid
ABS	-	Acrylonitrile Butadiene Styrene
PE	-	Polyethylene
PP	-	Polypropyelene
SLA	-	Stereolithography
SLS	-	Selective Laser Sintering
CAD	-	Computer Aided Design
CO_2	-	Carbon dioxide
MMC	-	Metal Matrix Composites
CMC	-	Ceramic Matrix Composites
PMC	-	Polymer Matrix Composites
HDT	-	Heat deflection temperature
NaOH	-	Sodium hydroxide
ρ	-	Density
m	-	Mass
V	-	Volume
˚C	-	Celsius
g	-	Gram
kg	-	Kilogram

CHAPTER 1

INTRODUCTION

1.1 Background

3D printing is not a new as we think. 3D printing turned out to be such a hotly debated issues and they were trusted that it was another innovation while it was protected as mid-1980s. From 1980s until now, this technology is picking up broadly and progressively complex. One of the techniques of 3D printing that widely used is Fused Deposition Modelling (FDM). Since FDM technology is the most prevalent contemporary technology to make products, all manufacturers will compete to deliver better products. So, the first thing should consider for create better products is they need to emphasize the material utilized for the production of the product. The material used or we called as filament will influence the mechanical properties and precision of the printed part, but also its cost.

The filaments are produced from thermoplastic that can blend with other additives or main pure polymers. With the improvement of this technology, numerous explorers are improved composite plastic. Among the methods utilized is to combine thermoplastic with synthetic fibres such as glass fibre. Glass is widely used because of its ability of high quality and solidness, impact resistance, chemical resistance and thermal stability at a low cost (Unterweger, 2014). In any case, this method will give issues that it cannot be discarded. This will influence nature and tourism industry of our nation. Therefore, this study aims to replace synthetic fibres with natural fibres that can provide better benefits to the environment while reducing manufacturing costs and improving product quality.

1.2 Problem Statement

Additive Manufacturing development has generally been utilized for prototyping application amid the item outline and advancement stage in various mechanical segments. However, 3D printed models have constrained mechanical properties and the printed parts usually cannot fulfil mechanical requirements for practical applications. As a result, this issue has offered rise to another idea of 3D printing procedure in view of adding filaments to the polymeric material grid. It is realized that the polymers created by FDM lose some part of their properties and have a tendency to be less stiff materials (Ting & Shen, 2017). Hence, by adding fibres will be one of the solutions for enhances mechanical properties to the original material. The innovative ventures have additionally shown the enthusiasm on the characteristic fibre like flax, hemp, Jute, coconut and sisal for the production of new things. Natural fibre is a fascinating contrasting option to engineered fibre for the composite innovation. The regular filaments are more affordable and have better solidness in regards to weight appeared differently in relation to fabricated fibre (Pandey, 2015). Therefore, with innovation in plastic composites, a study will be conducted to produce a new product that is wire filament as a feedstock for FDM which are made from a thermoplastic composite that reinforced by sugarcane bagasse.

1.3 Objective

The objectives of this project are:

i. To develop a new filament wire from sugarcane bagasse fibres reinforced plastic (SCBRP) by using extrusion process.
ii. To study the flow and deformation of sugarcane bagasse fibres reinforced plastic (SCBRP) by rheology testing.

1.4 Scope

This project will be focused on how to develop a new wire filament from natural fibre which is sugarcane bagasse that will reinforce thermoplastic composites. Furthermore, the types of thermoplastics such as Acrylonitrile Butadiene Styrene (ABS), Polylactic Acid (PLA), Polyethylene (PE) and others need to be studied to identify what type is appropriate and produce stronger structure after mixing to produce such composites. To develop this filament, the determination of which part in sugarcane gives the optimum content of fibre that will give more strength to composite need to be considered. Not only that, some processes such as alkalinised, dried and blending process are important to produce the fibre. Furthermore, the parameter in the extruder machine also need to study which are the temperature and speed setting.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This project is to develop a wire filament from sugarcane bagasse as a feedstock for Fused Deposition Modelling (FDM) which is made by extrusion process. This literature review is a combination of information gathered from various sources such as journals, articles, reviews, websites and books. Those sources are related to additive manufacturing, 3D printing, FDM and research about materials used.

2.2 Additive Manufacturing (AM)

Additive manufacturing (AM) or also known as 3D printing, rapid prototyping (RP) or freeform fabrication was inspired by Scott Crump at the end of 80's and was marketed in 1990 (Srivastava, 2017). Industry reports demonstrates that AM is an adaptable advancement and one that still cannot appear to accomplish its full assurance, particularly in the field of composite (Cerneels, Voet, Ivens, & Kruth, 2013). Exactly 3D printing advancements utilize dissolving material to make the layers. Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM) and Stereolithography (SLA) are among the examples of process that utilized for printing. Figure 2.1 shows the types of additive manufacturing processes.

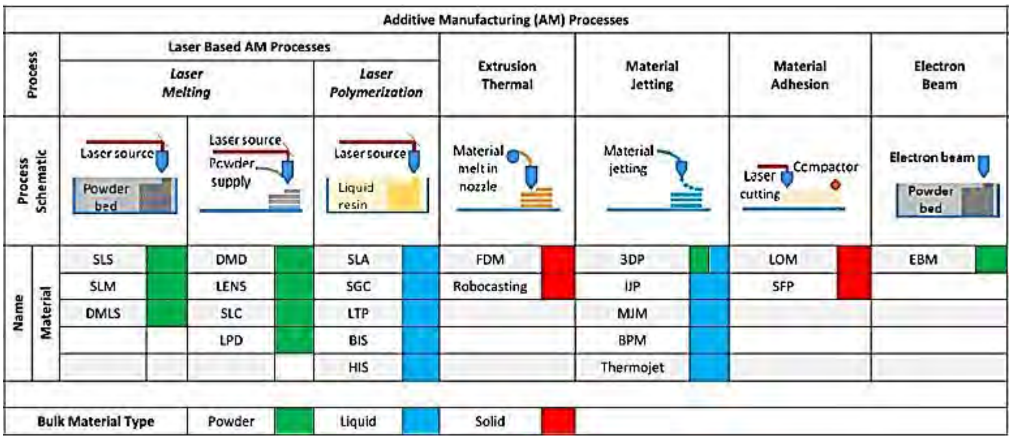

Figure 2.1: Types of AM (Sunpreet Singh, 2017)

Today, this technique has become most popular invention in manufacturing industry because of the ability to develop flexible design, high complex and also can reduce the production cycle (Ting & Shen, 2017). Not only that, there are few advantages of RP process especially it can convey parts free of geometrical objectives and gives complete in plan and development (Cerneels et al., 2013).

2.2.1 Fused Deposition Modelling (FDM)

FDM is a standout amongst the most used additive manufacturing technique today because of its capability to make extremely complex geometries, the real research issues have been to adjust capacity to deliver stylish engaging looking items with usefulness (Onwubolu & Rayegani, 2014). FDM technology is a technique build parts layer upon layer by heating thermoplastic material to a semi liquid state and extruding it according to CAD information. Figure 2.2 shows the FDM process.

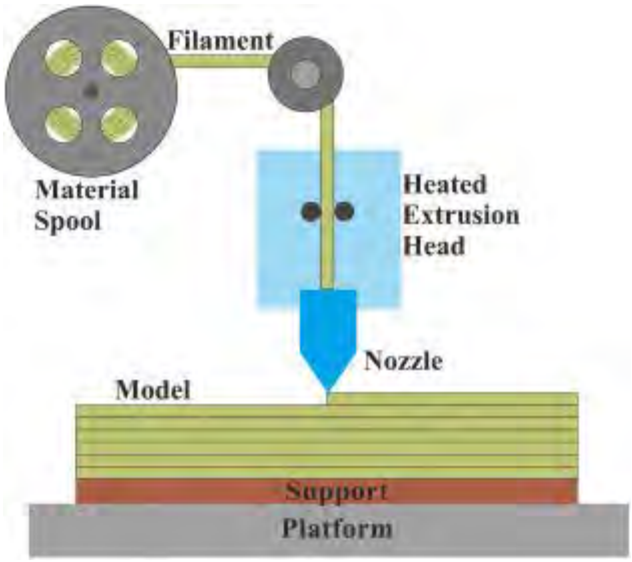

Figure 2.2: FDM Process

In FDM printer, the nozzle is fed a long plastic filament from a spool which are melted and drawn on the platform immediately. Those nozzle moves should put those material in the correct zone on create the model layer by layer. At the point when the layer is drawn, the platform brings down by one layer thickness with the goal that printer may begin for the accompanying layer. FDM utilizes two materials to execute a print work, first showing the material, which goes about as framework (Pandey, 2015).

2.2.2 Stereolithography (SLA)

Stereolithography (SLA or SL; generally called stereolithography contraption, optical manufacture, photo solidifying, or resin printing) is a sort of 3D printing innovation utilized for making models, prototypes, patterns, and generation of parts in a layer by layer fashion utilizing photo polymerization, a procedure by which light makes chains of atoms connect forming polymers. The model is at first composed through a CAD programming, the CAD information record is changed over into cuts of known measurements and exchanged to the stereolithographic contraption for building (Ruiz et al. , 2015) . The SLA procedure uses vat photo polymerisation. An UV bar or laser shaft is coordinated over a vat with photopolymers. The photopolymers harden when struck by the beam. The fluid vat (bowl) contains a stage that is submerged between each layer and the procedure proceeds until the requested 3D article is made. At the point when the procedure is done, the article is evacuated from the vat. When the article is printed, advance treatment is vital. Figure 2.3 shows the SLA printing process.

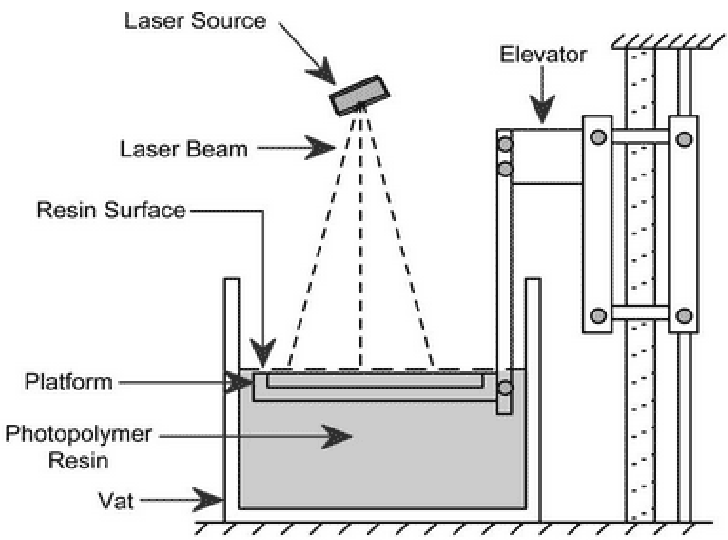

Figure 2.3: SLA Printing Process

Nowadays, SLA becomes the most technique that can develop precise form of part in 3D printing. There are two main types of SLA Technology which are laser based (typically abbreviated as SLA) or projection based (abbreviated DLP for Digital Light Projection). SLA development is greatly adaptable and it can be utilized when precision is the general need and where frame, fit and get together are essential. The tolerances on a SLA part are usually less than 0.05 mm, and this development offers the smoothest surface complete of any added substance producing process. Considering the level of quality SLA can achieve (case study), It is particularly helpful for making exceptionally exact throwing designs (e.g., for injection moulding (process page), casting and vacuum casting (applications/process page/contextual analysis) as well as functional prototypes (ODM), appearance models (ODM), and for performing structure and fit testing.

2.2.3 Selective Laser Sintering (SLS)

Selective Laser Sintering (SLS) is an additive manufacturing producing process that has a place with the powder bed fusion family. In SLS, a laser specifically sinters the particles of a polymer powder, melding them and building a section layer-by-layer. The materials utilized as a part of SLS are thermoplastic polymers that arrive in a granular form. SLS is utilized for both prototyping of functional polymer component and for small production runs, as it offers high plan flexibility, high precision and produces parts with great and steady mechanical properties, dissimilar to FDM or SLA. The abilities of the innovation can be utilized to its fullest however, just when the architect thinks about its key advantages and confinements. Figure 2.4 shows the SLS process.