INVESTIGATION THE EFFECT OF PRINTING PARAMETER ON PHYSICAL PROPERTIES OF 3D PRINTED PLA/SPF COMPOSITE

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

Signature	:	Mastura Mohammad Taha
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DEDICATION

To my beloved parent who are always supported me:

Roslan bin Abu Bakar

Rosilah binti Abdul Rahim

For my supervisor,

Dr Mastura binti Mohd Taha

For my families, my classmate and my friends

Who give a warm, supportive and opinion about this thesis. These characteristics that contribute to the setting that invariably required to realize the goals a heads.

ABSTRACT

Fused deposition modelling (FDM) is one of rapid prototyping (RP) technologies which uses an additive manufacturing approach. FDM machine are increasingly being used to manufacture parts for functional uses. The lowest cost of using FDM machine is the one factor that this approach become popular. FDM machine need filament to print the 3D printed part. Material such as Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS) is common use in FDM machine. FDM 3D printing can be a difficult procedure because it usually requires trial an error to find the right mix of factors (material, printer, process parameter and post-processing) to generate the desired result. This study is to investigate the effect of parameter on surface roughness, dimensional accuracy and physical appearance of 3D printing part by using PLA reinforcement Sugar Palm Fiber (SPF) filament. The type of filament used in this study is 10% fiber loading SPF mix with PLA and threated by NaOH + Silane solution. The 3D printed part needs to go through a few processes such as surface roughness testing, the measuring dimension of the sample and observation on physical appearance 3D printed part. The nozzle temperature was varied (180, 190 and 200°C) and layer thickness (0.2, 0.3 and 0.4 mm) to show its influence on surface roughness of the sample. Result have shown nozzle temperatures at 190 °C and layer thickness on 0.4 mm are the suitable parameter to get the smoothest surface of sample. Better performance to get the accurate dimension of the sample is using 190 °C and layer thickness 0.3 mm.

ABSTRAK

Pemodelan pemendapan bersatu (FDM) ialah salah satu teknologi prototaip pantas (RP) yang menggunakan pendekatan pembuatan aditif. Mesin FDM semakin digunakan untuk mengeluarkan bahagian untuk kegunaan berfungsi. Kos terendah menggunakan mesin FDM adalah salah satu faktor pendekatan ini menjadi popular. Mesin FDM memerlukan filamen untuk mencetak bahagian cetakan 3D. Bahan seperti Polylactic Acid (PLA) dan Acrylonitrile Butadiene Styrene (ABS) adalah biasa digunakan dalam mesin FDM. Pencetakan 3D FDM boleh menjadi prosedur yang sukar kerana ia biasanya memerlukan ralat percubaan untuk mencari gabungan faktor yang betul (bahan, pencetak, parameter proses dan pasca pemprosesan) untuk menjana hasil yang diingini. Kajian ini adalah untuk menyiasat kesan parameter terhadap kekasaran permukaan, ketepatan dimensi dan rupa fizikal bahagian cetakan 3D dengan menggunakan filamen Filamen Sugar Palm Fiber (SPF) tetulang PLA. Jenis filamen yang digunakan dalam kajian ini ialah campuran SPF pemuatan gentian 10% dengan PLA dan diancam oleh larutan NaOH + Silane. Bahagian cetakan 3D perlu melalui beberapa proses seperti ujian kekasaran permukaan, dimensi pengukuran sampel dan pemerhatian pada bahagian cetakan 3D rupa fizikal. Suhu muncung dipelbagaikan (180, 190 dan 200°C) dan ketebalan lapisan (0.2, 0.3 dan 0.4 mm) untuk menunjukkan pengaruhnya terhadap kekasaran permukaan sampel. Keputusan menunjukkan suhu muncung pada 190 °C dan ketebalan lapisan pada 0.4 mm adalah parameter yang sesuai untuk mendapatkan permukaan sampel yang paling licin. Prestasi yang lebih baik untuk mendapatkan dimensi sampel yang tepat adalah menggunakan 190 °C dan ketebalan lapisan 0.3 mm.

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LIST OF SYMBOLS AND ABBREVIATIONS

PLA	-	Polyactic Acid
ABS	-	Acrylonitrile Butadiene Styrene
FDM	-	Fused Deposition Modelling
CAD	-	Computer Aided Design
STL	-	Standard Tessellation Language
3D	-	Three Dimensional
AM	-	Additive Manufacturing
SPF	-	Sugar Palm Fiber
NaOH		Sodium Hydroxide

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CHAPTER 1

INTRODUCTION

1.1 Background

The additive manufacturing or 3D printing is the process of creating a three-dimensional object from a CAD model. The term "3D printing" can refer to a range of procedures in which material is deposited, fused, or solidified under computer control to create a three-dimensional object with material being added layer by layer (such as polymer, power grains or liquids) (Mostafaei et al., 2021). In the 1980s, 3D printing techniques were considered suitable for many types of production such as an aesthetic prototypes, and rapid prototyping was considered more appropriate (Agarwal et al., 2022). In 2019, 3D printing accuracy, repeatability, and material range have increased to the point that some 3D printing techniques are now considered acceptable as an industrial manufacturing or production technology, and the term additive manufacturing can be applied to 3D printing in the same way. One of the most appealing features of 3D printing is its capacity to make complex shapes or geometries that would be difficult to achieve by hand, such as hollow pieces or parts with an internal truss system to reduce weight. Fused deposition modelling (FDM), which uses a continuous thermoplastic filament, will be the most used 3D printing technology by 2020.

Technologies based on 3D printing or additive manufacturing, which can facilitate customised fabrication and provide fast and low-cost creation of complex three-dimensional goods, have attracted a lot of attention in recent years. This innovative technique has been employed in a variety of fields, including healthcare, engineering, pharmaceuticals, chemistry, electrochemistry and many more. (Stefano et al., 2022). 3D printing filament is thermoplastic feedstock for 3D printer that uses fused deposition modelling. There are many kinds of filament available with its own variety of properties and printing temperature. 3D printing filament is produced by heating, extruding and cooling plastic process to convert nurdles into completed product. The extruder temperature can be modified to meet the melting point of a specific filament, and most commercially available desktop printers can reach temperatures of 280 °C (Wojnowski et al., 2022).

Petroleum-based polymer composites will take longer to decompose, posing a significant environmental and climate risk. As a result of this issue, product makers are exploring for potential alternatives for their goods and products, such as eco-friendly composites. Bio composites, which combine natural fibres as a reinforcing element with a biodegradable matrix, are a friendly environment product made from natural resources that has a long useful life and is totally biodegradable after use. They are less hazardous, simple to manufacture, have a high strength to weight ratio and can help reduce carbon emissions. For this reason, bio fibre reinforced polymers have seen remarkable expansion in recent decades, particularly in the food and medical packaging industries. Natural fibre reinforced composites are biodegradable and recyclable, and will eventually replace petroleum-based polymer composites (Faruk et al., 2014). In automotive applications, bio fiber-based composites utilising Poly lactic acid (PLA) as a matrix component are extensively employed. (PLA)-based bio composites can be used in construction materials, products consumer, medical sector and application in aerospace, in addition to automotive applications (Felix Sahayaraj et al., 2021).

1.2 Problem Statement

3D printing can be a difficult procedure because it usually requires trial and error to find the right mix of factors (material, printer, process settings, and post-processing) to generate the desired result. Making judgments based on the available data from past research projects in this field is one way to lessen the number of rounds connected with this experimental methodology. Numerous researchers have made several attempts to increase part accuracy and surface smoothness by properly adjusting process parameters.

From the previous researcher (Chowdhry, 2022), The roughness of components created on the FDM 1650 machine is affected by layer thickness and part orientation, according to the results. They've also given an empirical formula for calculating part roughness. (Anita et al), uses the Taguchi approach is used to determine the effect of layer thickness, road width, and deposition speed on the surface roughness of a component made using the FDM process at three levels. The findings show that layer thickness, followed by road width and deposition speed, is the most influential process parameter impacting surface roughness. The preceding sections show that the qualities of rapid prototype parts are influenced by a variety of process-related aspects. Without expending additional costs in modifying developed hardware and software, quality can be considerably enhanced by properly adjusting build parameters.

However, variations in printing parameter settings can affect the dimensional precision of the printed object. FDM usage in large-scale production, where repeatability is crucial, is limited due to this constraint. Printing parameters need to adjust with suitable used of material to avoid a quality of 3D printed part. For a new material filament of FDM such a PLA-sugar palm, there are still don't have a suitable parameter to printed a part. As a result, the function of printing parameters, namely nozzle temperature, bed temperature, layer thickness and printing speed on the dimensional accurate of printed prototypes has been investigated in this study.

1.3 Research Objective

The main aim of this research is to investigate physical properties of fiber filled composite using 3d printing. The objectives are as follows:

a) To investigate about surface roughness, dimensional accuracy and physical appearance of 3D printing PLA/SPF composite parts using fused deposition modelling.

b) To analyse the correlation of PLA/SPF composite and printing parameter

1.4 Scope of Research

The scope of this research are as follows:

- Fused deposition modelling (FDM) 3D printing used to investigate physical properties of fiber filled composite.
- ASTM D368 use to print the sample using FDM 3D printing machine to fing the physical properties using PLA/SPF filament with 10% fiber loading mix and treated with NaOH + Silane solution.
- Collect data for analysis and compare the surface roughness, dimension accuracy and physical quality of filament uses.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Three-dimensional printing, also known as additive manufacturing, has allowed complex geometries to be manufactured to their final shape without the use of special tools, devices or jigs. It also a fabrication method that involves adding material together layer by layer to make a product. While polymer 3D printing has received a lot of attention in recent decades, composite material printing is still a relatively new field of study, with only one commercially available printer type for creating continuous fibre composites and a few more in the works. Finding the ideal mix of components (material, printer, process settings, and post-processing) to achieve the desired outcome is typically a trial and error process in 3D printing.

2.2 Computer Aided Design (CAD)

By developing rapid prototyping methods such as stereolithography (SLA), selective laser sintering (SLS), laminating object manufacturing (LOM), and three-dimensional printing, computer-aided design and manufacturing (CAD and CAM) has considerably enhanced traditional production design and manufacturing (3D printing). Rather than eliminating material, additive manufacturing creates a thing by adding it. The 3D pattern process is reduced to 2D layer stacking techniques, allowing an item to be made straight from its computer model. A geometric modeller, such as a solid modeller or CAD software, is used to create an item initially. The built-in tessellation method generates a simple and basic boundary representation that uses triangles to cover the solid's surface. Each triangle is defined by an outside normal and the positions of three ordered points. (Szilvási-Nagy & Mátyási, 2003).

2.3 Standard Tessellation Language (STL)

The STL format is used to save the CAD-created triangular meshes, which are then utilised as geometric details for actual things in a range of industrial applications, such as rapid prototyping and production. The mesh is then separated into layers with parallel cross-sections. The layers can be created in a variety of ways. In the file STL, which is a triangle facet portrayal, each triangle's vertex is arranged to match this requirement. This triangular mesh information is perfect for digital 3D demonstration and the STL file is the industry standard for digital input into all types of additive manufacturing equipment. (Agarwal et al., 2022). The built-in tessellation algorithm generates a simple boundary demonstration consisting of triangles that covers the solid's surface. An outward normal and three ordered point coordinates describe each triangle. These triangular meshes, which are recorded in STL format, are useful as actual geometry definitions in a variety of industrial applications, as well as for rapid prototyping and production. The mesh is then sliced into a series of layers with parallel cross-sections. Different ways are available for creating the layers (Szilvási-Nagy & Mátyási, 2003).