QUALITY AND PERFORMANCE INVESTIGATION OF 3D PRINTED ABS AND PETG PARTS

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

by

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2022

UTeM

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ABSTARCT

Sejak beberapa tahun kebelakangan ini, dunia telah mencapai kemajuan yang besar setiap hari baik dalam bidang penyelidikan mahupun pembelajaran. antara kemajuan besar yang dicapai ialah, kemajuan dari segi pembuatan. pembuatan termaju boleh membantu orang ramai melakukan tugasan seharian dengan lebih mudah dan menjimatkan masa. kemajuan yang dapat kita lihat dengan jelas ialah kemajuan daripada pembuatan bahan tambahan iaitu pencetak 3D. Pembuatan Tambahan (AM) ialah pembinaan objek tiga dimensi yang diambil daripada reka bentuk 3D yang dihasilkan menggunakan Reka Bentuk Bantuan Komputer (CAD) atau model 3D digital. Istilah percetakan 3D ialah pelbagai proses di mana bahan didepositkan dan dicantumkan bersama di bawah kawalan komputer untuk menghasilkan objek 3D melalui lapisan. Dalam penyelidikan ini, bahan ABS dan PETG digunakan sebagai filamen percetakan. Tujuan penyelidikan ini adalah untuk mengkaji kualiti dan prestasi bahagian cetakan 3D dengan menjalankan ujian mekanikal Skop kajian ini adalah untuk menghasilkan bahan dan parameter pencetak 3D terbaik untuk mencetak bahagian tersebut. Penyelidikan ini akan diadakan menggunakan pencetak 3D Fused Deposition Modeling (FDM) iaitu Ender 3 V2.

ABSTRACT

Over the past few years, the world has made great progress every day both in the field of research or learning. among the major progress achieved is, progress in terms of manufacturing. advanced manufacturing can help people to do day tasks more easily and save time. the progress we can see clearly is the progress from the manufacture of additives i.e. 3D printers. An Additive Manufacturing (AM) is the construction of three-dimensional objects taken from 3D designs produced using Computer Aided Design (CAD) or digital 3D models. The term 3D printing is a variety of processes in which materials is deposited and joined together under computer control to generate 3D objects by means of layers. In this research, ABS and PETG materials used as printing filament. The purpose of this research is to study the quality and performance of 3D printed part by conducting the mechanical test The scope of this research is to produce the best 3D printer material and parameter to print the parts. This research will be held using Fused Deposition Modelling (FDM) 3D printer which is Ender 3 V2.

DEDICATION

TO MY BELOVED FAMILY,

My mother Usharani, my father Rajendran and my brother R.Sujey Kumar.

For their support in my whole life through moral and financial

TO MY HONOURED SUPERVISOR,

Prof. Ir. Ts. Dr. Sivarao Subramonian

For his advice, support, motivation and patience during completion of this project

AND TO ALL MY COLLEAGUE,

For their encouragement, moral support, cooperation, and effort in this study.

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I am highly obliged in taking the opportunity to sincerely thanks to the head of JK PSM Committee, En. Nor Akramin bin Mohamad for giving me guidance and as well as providing necessary information regarding this project. Besides that, I also would like to thank the lecturers and panels involved for spending time to listen to my presentation in PSM I. All knowledge, opinions, and guidance I had received on that day will be used wisely and engraved on my mind for my future reference in applying the knowledge in the real world.

I would also like to express my gratitude to my parents and other members of my family for their unwavering support, encouragement they gave me throughout the duration of this project.

Last but not least, my thanks and appreciations goes to my friends and people who have willingly helped me out with their abilities. I have no valuable words to express my thanks, but my heart is full of the favor's receive from every person.

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3D	-	Three Dimensional
ABS	-	Acrylonitrile Butadiene Styrene
PETG	-	Polyethylene terephthalate glycol
FDM	-	Fused Deposition Modelling
SLS	-	Selective Laser Sintering
PLA	-	Polylactic Acid
CAD	-	Computer Aided Design
AM	-	Additive Manufacturing
DOE	-	Design of Experiment
ASTM	-	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

The first chapter discusses the overall objective of the research study, which was to provide an overview of the quality of 3D printed parts. This chapter discusses the study's background, problem statements, objectives, and scope.

1.1. Background Of Study

Performance, reliability, durability, serviceability, aesthetics, features, perceived quality, and conformance to specifications or standards are all ways to evaluate a product's or process's quality (Montgomery, 2008). According to the American Society for Quality (2016), quality control (QC) encompasses the observation techniques and activities necessary to ensure that quality criteria are met. Quality is a concept that is commonly used but seldom defined in postharvest investigations. Most of the post-harvest research (both physiological and technical) takes a quality-oriented product focus. Quality is described as a set of features chosen based on measurement accuracy and precision.

A 'quality' product has passed a series of quality inspections in this context. Rather than being unachievable, the inspections were based on attainable standards that are intended to reject 'defective' item. All objects that fulfil the monitoring body's fundamental standards are thus labelled as 'quality.' As a result, quality is the result of "scientific quality control" and standard observance. At each given time, a 'absolute' standard will be used to test the product;

those that fulfil the operationalized criteria will go beyond the quality check. The similar conformity to fundamental criteria is utilized to judge the quality of other rival items.

Quality is sometimes regarded as a subjective concept. There are two ways that quality might be viewed as relative. To begin with, the quality of a phrase is determined by the person who uses it and the context in which it is used. It might mean different things to different individuals at different times; in fact, it can mean different things at different times to different people. "Whose quality?" one could wonder. Quality's 'benchmark' relativism is the second. Some individuals use absolutes to determine quality. There's the undeniable, unmistakable absolute of excellence (or apodictic, as Husserl (1969) calls it). "Absolute [quality] is analogous to truth and beauty in nature. It's an ideal that can't be squandered." 1991 (Sallis & Hingley).

To put it another way, quality is measured in terms of absolute standards that must be met for a quality grade to be awarded (for example, the output has to meet a predetermined national standard). However, quality is proportionate to the 'processes' that result in the intended outputs in certain conceptualizations; rather, quality is proportional to the 'processes' that result in the desired outputs. A product has quality if, for example, it regularly satisfies its maker's promises for it, regardless of any absolute criteria. As a result, certain conceptions of excellence are more 'absolutist' than others.

3D printing, alternatively referred as additive manufacturing, is the process of converting a two-dimensional CAD model or digital three-dimensional model into a three-dimensional object. The term "3D printing" refers to a variety of techniques in which material is deposited, linked, or solidified under digital control to create a three-dimensional object using layers of material (such as polymers, liquids, or powder grains). In the 1980s, 3D printing technologies were considered suitable only to produce functional or aesthetically pleasing prototypes, and quick prototyping was a more appropriate term at the time. The terms "additive manufacturing" and "3D printing" can now be used interchangeably in the context of industrial production for some 3D printing processes. Hollow objects and products with internal truss systems for weight reduction can be created using 3D printing, and this is one of the most significant advantages of 3D printing. A thermoplastic filament used in Fused Deposition Modelling (FDM) will be the most popular 3D printing method by 2020.

3D printing works on a basic basis. Starting with nothing and adding material one layer at a time until the object is complete, an item is created. There are multiple natural examples of the procedure, and lower-tech versions, such as erecting a brick wall, have been called by various names for millennia. The current 3D printing craze is just a culmination of technology and practices that have been around for a long time. This chapter, on the other hand, focuses on a few key technological and business advancements that came together to make consumer 3D printing affordable. We'll start with natural processes that are like 3D printing to give you a clear mental picture of how it works. Even though 3D printing looks to be a cutting-edge method, many species have been doing it for decades. Molluscs, which provide us with seashells, are among nature's numerous 3D printers. Molluscs begin to deposit calcium carbonate to their outer shell as they get larger, allowing the expanding animal more room within. Lines of growth may be seen on seashells if you look closely.

Figure 1.1 Product of natural '3D printer' (Luméa et al., 2018)

Figure 1.1 shows the natural product of '3D printer', as the shell develops longer and wider, it thickens, preventing it from becoming fragile. In contrast to the printers described in this book, the shell is secreted and condensed by the being's environment rather than being laid down with a nozzle. Nonetheless, the results could be stunning. Selective binding, selective solidification, and selective deposition are all examples of additive manufacturing. The acronyms SLS, SLA, and DLP are commonly used to describe these technologies, as explained in more detail in the following section. These three categories are being established to assist make sense of the vast array of technologies available and to better organise them.

Binding procedures use chemicals or heat to bind the powder's particles together to create a 3D printed object (metal and gypsum are common materials). Laser sintering (SLS) is an example of this, in which one layer of minced material is fused at a time. Fusion of the first layer to the platform is followed by another layer of powder, and so on. The powder acts as a support for the print, enabling for the development of extremely detailed and delicate motifs. However, working with the fine powder can be challenging, and printers can be expensive.

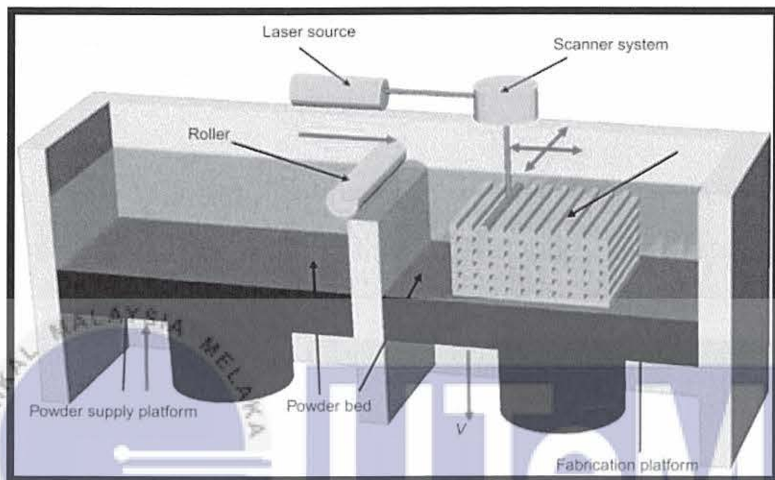

Figure 1.2: Schematic diagram of SLS 3D printing process*(Gan et al., 2020)*

The schematic diagram in Figure 1.2 illustrates the SLS 3D printing process, which creates a solid object from a vat of fluid by selectively utilizing energy to solidify the liquid one layer at a time. First, a platform is constructed and then lowered into the molten metal (or, in certain situations, a develop platform is pulled up out of the liquid). Figure 1.3 show Stereolithography (SLA) which is one example, which hardens a single layer using UV light, a laser, or, in some cases, a digital light projection (DLP) imager. In any event, the model must be cured periodically afterward, and the resin can be challenging to deal with. There are SLA desktop printers currently on the market, but they are expensive than filament-based desktop printers.

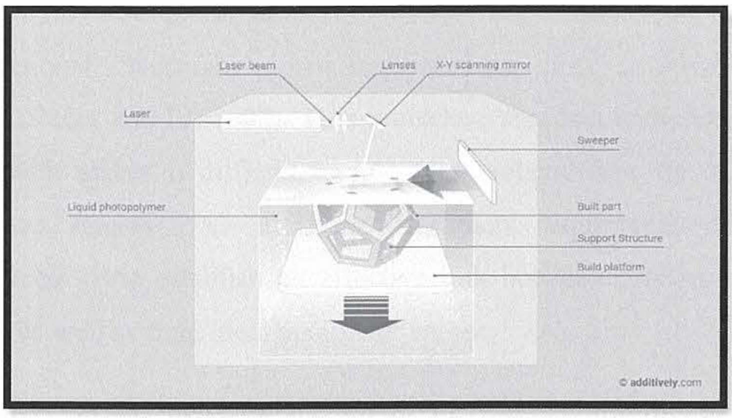

Figure 1.3: Schematic diagram of SLA 3D printing process (FacFox *et al.* 2018)

3D printing is a one-of-a-kind manufacturing method in which there is no time gap between R&D and mass production. There is always a time gap between establishing industrial capacity and procuring raw materials in traditional production processes. This research investigated the issues with 3D printing quality and performance. To enhance and boost consumer happiness, 3D printed objects must undergo continuous evolution.

1.2. Problem Statement

3D printing is gaining traction in the manufacturing sector daily due to its ability to create difficult structures and mass customization. Using additive manufacturing principles, this method of printing can create even the most complex shapes that would otherwise be impossible or extremely difficult to construct using traditional subtractive methods (Gu and Li, 2002). Layer-by-layer manufacturing is a development of rapid prototyping methods that are progressively used in industrial process chains to shorten the time and cost of product development.

Additive manufacturing technologies are required to produce high-quality components. Increased degrees of dimensional precision are required to meet FDM's growing demand for higher-quality manufactured products. Maintaining dimensional precision with close tolerances ensures the produced item's dimensional stability and reproducibility in such applications. The process parameters have a major impact on the final quality of the FDM object. Due to the variety of conflicting parameters that affect the dimensional accuracy individually or collectively through the interaction of several parameters, FDM-manufactured parts exhibit dimensional inaccuracy when compared to other additive manufacturing processes such as SLS (Gu and Li, 2002). This procedure entails a complex mechanism for producing items, which makes it difficult to fully comprehend how the factors affecting dimensional precision interact. As a result, designers, equipment developers, and manufacturing engineers must establish an effective link between process parameters and dimension accuracy, as well as final ideal parameter values.

The researchers would evaluate the effect of various printing parameters on a dimensionally accurate 3D printed item. To meet performance standards in 3D printing, the overall quality of the manufactured objects must be improved. However, until recently, little attention was paid to the material quality of filaments, which could be attributed to a lack of straightforward procedures for quality testing material filaments. Mechanical properties of 3D printed components are highly dependent on the process design and processing conditions. Despite this, it has several issues that are connected in some way to the material discontinuity caused by the laying down process (Tumbleston *et al.*, 2015). Due to the dependence of the measured parameters on the orientation of the workpiece during printing, as well as the large number of contacts generated by inter-filament necking, mechanical performance issues may arise. All these factors contribute to mechanical anisotropy and performance degradation (Kalita *et al.*, 2003).

In part due to the fact that the FDM process is dependent on the selection of specific process parameters, the mechanical qualities of the final created item produced by this method are inferior to those produced by traditional methods (e.g., injection moulding). However, the following factors limit the use of FDM 3D printing: the mechanical strength of FDM printed items is often lower than that of injection moulded items due to weak areas between layers (Dawoud, Taha, and Ebeid, 2016); thermoplastic materials tend to shrink during the cooling process, resulting in printed product warp (Dawoud, Taha, and Ebeid, 2016); and thermoplastic materials shrink during the cooling process, resulting in printed product warp (Agag, Koga and Takeichi, 2001).

The FDM process is commonly used for rapid prototyping since it is inexpensive, simple, and allows for the use of a variety of materials. Acrylonitrile Butadiene Styrene (ABS) and Polyethylene Terephthalate Glycol (PETG) are the most utilized materials in the FDM process due to their availability readiness and ease of blending with other materials such as