UNIVERSITI TEKNIKAL MALAYSIA MELAKA

COMPREHENSIVE STUDY ON SELECTIVE LASER SINTERING 3D PRINTER POLYAMIDE 12 RECYCLE PARAMETER AND DIMENSION MEASUREMENT ACCURACY EFFECT ON MAINTENANCE APPLICATION

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Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Maintenance) with Honours

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2022

DECLARATION

I declare that this thesis entitled " Comprehensive study on Selective Laser Sintering 3D printer POLYAMIDE 12 RECYCLE Parameter and Dimension Measurement Accuracy Effect on Maintenance Application" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Signature :

Name : Anas Naufal Bin Abd Latiff

Date : 11/1/2023

APPROVAL

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 Mechanical Engineering Technology (Maintenance) with Honours.

Signature :

Supervisor Name : Mohammad Rafi Bin Omar

Date : 11/1/2023

DEDICATION

This thesis is dedicated to my dearest father and late mother, supervisor, family's members, and friends who supported me throughout my study.

ABSTRACT

The fact that numerous 3D printed products have been developed, there are still issues with the printed product's physical properties and the accuracy of 3D printing produced product. This study examines comprehensive study on SLS 3D printer polyamide 12 recycle parameter and dimension measurement accuracy effect on maintenance application. A variable parameters of laser beam power and layer thickness recycled material were used for the Polyamide 12. The test specimens were prepared at different process parameters using the SLS 3D printer. The hardness, surface roughness, and surface morphology were tested. These samples were tested in accordance with ASTM D638-(IV) for tensile strength and roughness using a 10 mm x 10 mm coated sample prepared for scanning in an electron microscope. The SLS Farsoon 402P machine calibration block was used to measure and analyze how accurate the machine's X and Y axes were in terms of their measurements. This project will compare and validate 3D scanner data accuracy. By doing this, the researcher will get an exposure to reverse engineering software and fabricate experiment specimens using 3D printer machines. After run the experiment, the result to be expected are hardness test, roughness test, surface morphology, and dimension accuracy for each different parameter settings of SLS 3D printer machine on the specimens.

ABSTRAK

Hakikat bahawa banyak produk bercetak 3d telah dibangunkan, masih terdapat masalah dengan sifat fizikal produk bercetak dan ketepatan produk percetakan 3D yang dihasilkan. Kajian ini mengkaji kajian komprehensif mengenai SLS 3D printer polimida 12 recycle parameter dan pengukuran dimensi kesan ketepatan pada aplikasi penyelenggaraan. Serbuk dikitar semula digunakan untuk komposisi Polimida 12. Spesimen ujian disediakan pada parameter proses yang berbeza menggunakan pencetak SLS 3D. Kekerasan, kekasaran permukaan, dan morfologi permukaan diuji. Sampel ini diuji mengikut ASTM D638 - (IV) untuk kekerasan dan kekasaran menggunakan sampel bersalut 10 mm x 10 mm yang disediakan untuk diimbas dalam mikroskop elektron. Blok kalibrasi mesin SLS Farsoon 402P digunakan untuk mengukur dan menganalisi ketepatan paksi X dan Y mesin dari aspek ketepatan dimensi. Projek ini memberi tumpuan kepada analisis SLS 3D parameter bahan pencetak bahan kitar semula. Projek ini akan membandingkan dan mengesahkan ketepatan data pengimbas 3D. Dengan melakukan ini, penyelidik akan mendapat pendedahan untuk membalikkan perisian kejuruteraan dan membuat blok eksperimen menggunakan mesin pencetak 3D. Setelah menjalankan eksperimen, hasil yang diharapkan adalah ujian kekerasan, ujian kekasaran, morfologi permukaan, dan ketepatan dimensi untuk setiap parameter mesin pencetak SLS 3D yang berbeza.

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Last but not least, from the bottom of my heart a gratitude to my beloved siblings, for their encouragements and who have been the pillar of strength in all my endeavors. My eternal love also to all my friends, for their patience and understanding. I would also like to thank my beloved parents for their endless support, love and prayers. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

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LIST OF SYMBOLS AND ABBREVIATIONS

PR	-	Parameter
SLS	-	Selective laser sintering
PA-12	-	Polyamide-12
CP	-	Composition
SP	-	Sample
SEM	-	Scanning electron microscopy

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CHAPTER 1

INTRODUCTION

1.1 Introduction

A lot of industries nowadays acknowledged the 3D printing technologies as the top or the sixth manufacturing ranking. Established in the 1980s, 3D printing uses various materials like metals and plastics to make three-dimensional goods layer by layer based on a digital model, rather than using physical labor or mechanization. There has been a massive expansion in this field, with hundreds of thousands and numerous manufacturing equipments of 3D printed objects. The word 3d printing representing processes in technologies that offer a full capability for production parts and product in varying materials. Basically, the what all technologies of manufacturing have in common are the substrate of molding between layers in an additive process is quite different with the traditional methods of manufacturing regarding the subtractive ways or casting processes (Team, 2021).

Many of 3D printing technologies have been developed with each respective functional. According to ASTM standard F2792 for ASTM catalogue, it divided into seven groups. My type of 3D printing to be used is Selective Laser Sintering (SLS). This method uses laser to melt or sinter the powder to fuse the powder together. The powder bed fusion is the example of Selective Laser Sintering. Selective Laser Sintering is being used to make plastic, metal, and ceramic object. To build 3D product, a high laser beam power is being used to sinter the selected material such as polymer. Another thing is, electron beam melting augment an energy source to lit up the material. (Shahrubudin et al., 2019)

The Farsoon 402P series of Selective Laser Sintering not only for plain manufacturing geometry, but it also bring the state of art itself. It is a rapid prototyping and for additive manufacturing wielders. High in performance, multi-zone, imaging components, thermal stability advancements, removeable powder cylinders, bi-directional single powder feed system make the Farsoon an extrremely productive and efficient resolve for the high application demands. Farsoon technologies determined to a greater innovation by delivering a complete freedom to function with any open platform application. With perfect accessibility in machine parameters and settings, users can opt to any desired materials to meet the production or prototyping requirement. Polymers of 3D printing technologies are vastly used due to its liquid form and melting point are low in cost, high mobility product processing, and low in weight.(Farsoon Technologies, 2017)

This study aims to optimize the highest accuracy parameter of PA-12 for specimen production using SLS 3D printer and to obtain high precision and accuracy of the produced specimen. In addition to it, to acquire the guideline for a superior parameter.

1.2 Problem Statement

By thoughtfully introducing material where it is needed, Additive Manufacturing (AM) processes enable the efficiency of bottom-up development of 3D objects. These approaches have improved in taste and texture, cost, complexity, resolution, and quality. Because Selective Laser Sintering produces parts with no supports, the design possibilities are practically limitless. Unlike traditional melt extrusion with strong shear mixing and shear fluidity, it does not compact during processing, making it a crucial 3D printing approach for the production of porous segregated structures. The disadvantage of the SLS 3D printer is that it takes a long time to print and the necessary dimensions may not be obtained because to shrinkage.

SLS parts have a grainy surface finish and a significant degree of interior porosity, so post processing may be required to obtain a smooth surface finish or watertightness. When compared to virgin polyamide-12, recycled polyamide-12 has a lesser strength.

More research is needed to understand the capacity of selective laser sintering 3D printers in order to produce geometry component accuracy. The content of a selective laser sintering 3D printer composition and parameter often necessitates a thorough examination because it affects the quality of the printed result.

Therefore, this study aims to optimize the highest accuracy parameter of PA-12 for specimen production using SLS 3D printer and to obtain high precision and accuracy of the produced specimen. In addition to it, to acquire the guideline for a superior parameter.

1.3 Research Objective

a) To optimize the parameter of SLS 3D printing machine recycle materials of Polyamide 12.
b) To obtain high precision and accuracy of the produced specimen.
c) To acquire the guideline for a superior parameter of polyamide 12

1.4 Scope of Research

This study is limited to the following scope:

a) Optimization of 3D printer parameter using Taguchi Method.

b) Testing samples of polyamide 12 by using few of testing machines which are for hardness test, roughness test, and surface morphology.

c) Validate the precision of 3D printed specimens by using calibration block and standard vernier caliper.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

By continuously adding materials to a geometrical representation, digital fabrication technology, also known as 3D printing or additive manufacturing, builds physical items from a geometrical representation. 3D printing is a new technology that is rapidly gaining traction. 3D printing is now widely used all around the world. In the fields of agricultural, healthcare, automotive, locomotive, and aviation, 3D printing technology is increasingly being used for mass customization and fabrication of any form of open source design. 3D printing uses layer-by-layer deposition of material to create an object directly from a computer-aided design (CAD) model. In figure 2.1 showed an overall elementary structure of 3D printing technology

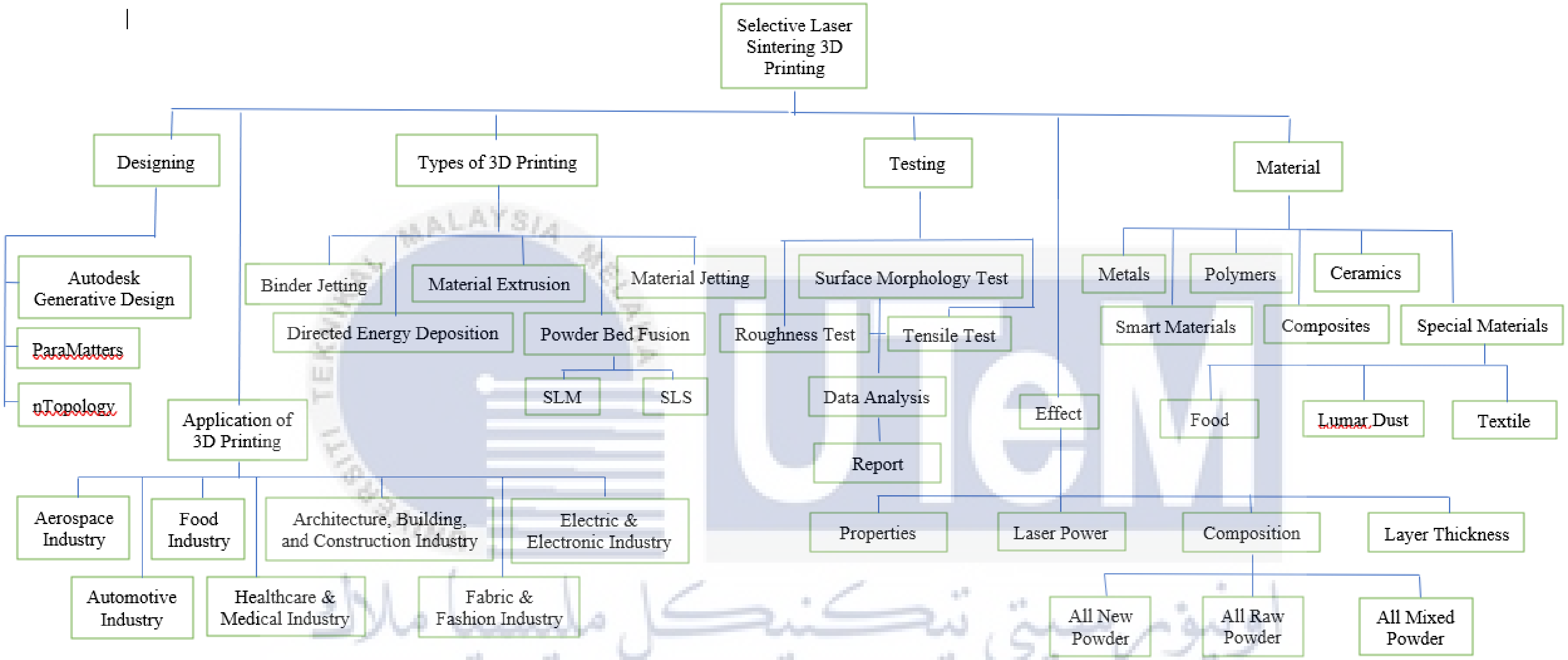

Figure 2.1 Elementary structure of 3D printing technology

2.2 Types of 3D Printing

Different kinds of 3D printing technologies have been made, and they work in different ways. Figure 2.2 depicts a typical system structure for FDM 3D printing. In accordance with ASTM Standard F2792, ASTM categorised 3D printing technologies into seven distinct categories, including binding jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination, and vat photopolymerization. There are no disagreements regarding whether machine or technology is more effective because each 3D printer has its own specialised applications. The use of 3D printing technology is no longer limited to prototyping and is increasingly being applied to the production of a wide variety of items..(Shahrubudin et al., 2019)

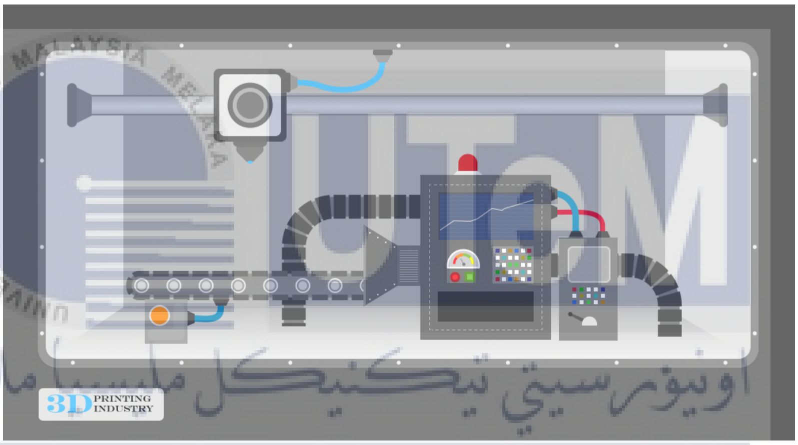

Figure 2.2 Typical 3D printing system (FDM)

2.2.1 Binder Jetting

Binder jetting is a quick prototyping and 3D printing technique using the deposition of a liquid binder to combine powder particles. In order to form the layer, binder jetting technology shoots a chemical binder over the unfolded powder. From sand, binder jetting would be utilised to generate casting designs, raw sintered products, and comparable high-volume items. Binder jetting can print metals, sands, polymers, hybrids, and ceramics, among other substances. Binder jetting is capable of printing metals, sands, polymers, hybrids, and ceramics. Certain materials, such as sand, require no further processing. In addition, the binder jetting procedure is simple, economical, and quick since powder particles are linked together.

2.2.2 Directed Energy Deposition

Binder jetting is a quick prototyping and 3D printing technique using the deposition of a liquid binder to combine powder particles. In order to form the layer, binder jetting technology shoots a chemical binder over the unfolded powder. From sand, binder jetting would be utilised to generate casting designs, raw sintered products, and comparable high-volume items. Binder jetting can print metals, sands, polymers, hybrids, and ceramics, among other substances. Binder jetting is capable of printing metals, sands, polymers, hybrids, and ceramics. Certain materials, including such sand, require no further processing. In addition, the binder jetting procedure is simple, economical, and quick since powder particles are linked together.

2.2.3 Material Entrusion

3D printing technology based on material extrusion can be used to print multi-color and multi-material prints of plastics, living cells, or foods. This procedure is widely used among consumers, and the costs are quite low. Similarly, this process can generate fully functional product parts. The first example of a material extrusion system is fused deposition modelling (FDM). FDM was developed in the early 1990s, and the main material used is polymer. FDM works by extruding thermoplastic filaments such as ABS and PLA through a heated nozzle, allowing the material to melt and be applied layer by layer on a build platform.

2.2.4 Powder Bed Fusion

Powder bed fusion is accomplished through selective laser sintering (SLS). To fuse or melt the material powder together, either a laser or an electron beam is used. Metals, polymers, ceramics, composites, and hybrids are some of the materials used in this process. The most basic example of powder-based 3D printing technology is selective laser sintering (SLS). SLS is a 3D printing technology that works quickly and accurately, and differs surface finish. Selective laser sintering can used to produce metal, plastic, and ceramic objects. SLS used a high-power laser to sinter polymer powders to fabricate a 3D product. In the meantime, SHS technology is another part of 3D Printing technology uses a head thermal print in the process to melt the thermoplastic powder to make 3D printed product. Lastly, electron beam melting augments an energy source to warm up the material.