COMPREHENSIVE STUDY ON SELECTIVE LASER SINTERING 3D PRINTER POLYAMIDE 12 RECYCLE COMPOSITION EFFECT

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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**A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Comprehensive study on SLS 3D printer polyamide 12 recycle composition effect to strength and orientation effect on automotive 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

Signature :

Name : *(Mohamad Akmal Hakimi Bin Norazmi).*

Date : 6/1/2022

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 (Automotive Technology) with Honours

Signature :

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DEDICATION

Firstly, i would want to express my profound appreciation to my supervisor, Sir Mohammad Rafi Bin Omar and co-supervisor Dr. Muhammad Ilman Hakimi Chua Bin Abdullah for their invaluable direction, admonition, and unrelenting support during the completion of this project. I really value and implement all of his suggestions and oversight that contribute to the completion of this project. Every challenging endeavor demands both individual work and the counsel of specialist, especially those who area near to our hearts. I devote my endeavor first and foremost to my lovely parents. Thank you from the bottom of my heart to my parents for their continuous support and for being a pillar of strength throughout my experience. In addition, I would like to expiree my gratitude to my fellow friend for the advice and keep reminding me to be strong while doing this project

ABSTRACT

The use of 3D printing has made it possible to fabricate both parts and products in this century. The product that needs to be produced using a 3D printer, which has become the central component in many technologies, but there are still problems with the printed product's physical qualities and surface morphology. The purpose of this experiment is to demonstrate the effects of significant Selective Laser Sintering (SLS) 3D printer parameters by comparing the technical data obtained from experiments using laser powers of varying values and layer thicknesses of Polyamide12 (PA-12). In addition to this, the purpose of the experiment is to establish which parameter, given varying values of laser power and layer thickness, will best suit the unique conditions. Using the SLS 3D printer, the test specimens were created with varying settings for the process parameters and percentages of the material composition. Tests were run to determine the stress, surface roughness, and surface morphology. employing a coated sample that was 10 millimetres by 10 millimetres and was prepared for scanning in an electron microscope in accordance with ASTM D638-(IV) for stress and roughness The results of the tensile test demonstrated that the strength of the material will deform at maximum tensile stress depending on the magnitude of the laser power and the layer thickness. Additionally, the surface roughness was reduced. Furthermore, According to the findings of this experiment, the optimal parameters for working with polyamide 12 are a layer thickness of 0.06 millimetres and an output power of 80 watts from the laser. Following the completion of the experiment, this was judged to be the general result.

ABSTRAK

Penggunaan percetakan 3D telah memungkinkan untuk membuat kedua-dua bahagian dan produk pada abad ini. Produk yang perlu dihasilkan menggunakan pencetak 3D, yang telah menjadi komponen utama dalam banyak teknologi, tetapi masih terdapat masalah dengan kualiti fizikal dan morfologi permukaan produk bercetak. Tujuan eksperimen ini adalah untuk menunjukkan kesan parameter pencetak 3D Selective Laser Sintering (SLS) yang ketara dengan membandingkan data teknikal yang diperoleh daripada eksperimen menggunakan kuasa laser yang berbeza-beza nilai dan ketebalan lapisan Polyamide12 (PA-12). Di samping itu, tujuan eksperimen adalah untuk menentukan parameter mana, berdasarkan nilai kuasa laser dan ketebalan lapisan yang berbeza-beza, paling sesuai dengan keadaan unik. Menggunakan pencetak SLS 3D, spesimen ujian dicipta dengan tetapan yang berbeza-beza untuk parameter proses dan peratusan komposisi bahan. Ujian dijalankan untuk menentukan kekuatan tegangan, kekasaran permukaan, dan morfologi permukaan. menggunakan sampel bersalut 10 milimeter kali 10 milimeter dan disediakan untuk mengimbas dalam mikroskop elektron mengikut ASTM D638-(IV) untuk kekuatan tegangan dan kekasaran Keputusan ujian tegangan menunjukkan bahawa kekuatan bahan akan berubah bentuk pada tegasan tegangan maksimum bergantung pada magnitud kuasa laser dan ketebalan lapisan. Selain itu, kekasaran permukaan telah dikurangkan. Tambahan pula, menurut penemuan eksperimen ini, parameter optimum untuk bekerja dengan poliyamide 12 ialah ketebalan lapisan 0.06 milimeter dan kuasa keluaran 80 watt daripada laser. Selepas selesai eksperimen, ini dinilai sebagai keputusan umum.

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LIST OF SYMBOLS AND ABBREVIATIONS

mm	-	Milimeter
Nm	-	Newton meter
Kg	-	Kilogram
µm	-	Micrometer
kN	-	Kilo newton
N/mm	-	Newton per milimeter
W	-	Watt
Mpa	-	Mega pascal

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Literature review

This chapter is to explain about the introduction of polyamide -12 and the history of this material. It very important because we can achieve objective and problem statement that already set. In the same time this chapter also will explain about 3D printer that use that is Selective Laser Sintering (SLS).

1.2 Introduction

Additive manufacturing (AM) is one of cutting-edge technology has exploded in popularity over the last decade. C. Hull (1986) identified this manufacturing as a basic concept of compacting material layer by layer to create items from 3D design data (Martynková et al., 2021). The optimization of mixed materials permits the development of various parts with a variety of shapes and functional designs that are not possible with standard mechanical processes (Santonocito, 2020). This new method can process a wide range of materials. Many AM processes different type in terms of the materials that more suitable, the architecture of 3D printers (Martynková et al., 2021)

Selective Laser Sintering technology that combines a dozen various layer-by-layer processes into one. Powder Bed Fusion (PBF) in which a directed heating temperature, example like a laser, is used to target partially sintering or entirely melting, resulting in a hardened multi-layer of fused powder (Prototyping et al. 2019). Powder Bed Fusion (PBF) is a commonly utilized material in the SLS technology, however polyamides are the most popular semi-crystalline polymers for SLS, with polyamide 12 dominating production for its capacity to provide large components for typical industrial products.

Polyamide 12 powder-based materials offer excellent mechanical and thermal characteristics (Martynková et al., 2021). However, as compared to waste, the volume ratio of a polyamide powder translated to the printed product is relatively modest. Finished part manufacture typically consumes a tiny percentage of overall plastic powder use. Thermal stress during pre-heating, sintering, and cooling causes the residual powder to lose its physical and chemical characteristics(Yang et al., 2020). For economic and environmental reasons, recurrent use of a previously processed powder material is required for selective laser sintering (SLS) 3D printing.

It has been discovered that laser power and layer thickness have a significant impact on surface roughness and dimensional accuracy. Furthermore, the effects of interactions between process variables are significant and should be accounted for in surface roughness and dimensional accuracy models. The energy density plots are used to explain the nonlinear behaviour of some variables and their interactions on surface roughness. According to the findings in the studied domains, decreasing layer thickness tends to reduce surface roughness. However, lowering the laser power raises the surface roughness. (Imanian & Biglari, 2022)

1.3 Problem Statement

SLS, also known as selective laser sintering, is quickly becoming one of the most valuable manufacturing technologies in the medical, aerospace, and automotive industries. Which has expanded at a rate that is comparable to an exponential over the past ten years. The fundamental idea behind this method, which was first developed by C. Hull in the year 1986, is to minimise the amount of material needed to construct an item based on data from a 3D design. These methods can be advantageously applied to any and all types of additive manufacturing. However, conducting a stress test on a material provides significant failure into the tensile mechanical properties of the material being tested. A steady decline in the component's surface quality or manufacturing faults that produce initially manageable challenges could lead to the eventual failure of the component over time. If an appropriate surface feature analysis is performed to discover the possible faults inside the material, then both the manufacturing process and the final product are enhanced, and the final product is better able to be applied to its intended application.

1.4 Research Objective

The primary objective of this project is to investigate several approaches that have the potential to achieve high levels of strength and durability in the product specimens with reasonable accuracy. Specifically, the objectives are as follows:

a. To investigates the influence of parameter setting in Selective Laser Sintering (SLS) 3D printer on the material strength of Polyamide-12 (PA-12).

b. To Fabricated specimen using method by using Selective Laser Sintering (SLS) 3D printers samples by following according to the American Society for Testing and Materials (ASTM)

1.5 Scope of Research

This project will be forces on material strength and durability by using 4 type method with different value laser power and layer thickness. Testing a material's stress offers information regarding the material's tensile mechanical properties. These characteristics can be represented on a graph in the form of a stress-strain curve to display information such as the point at which the material failed, in addition to providing information on characteristics such as the yield strength, modulus of elasticity, and strain.

Other that, surface roughness is one of significant factor in establishing its behavior in contact with other objects and the surrounding space. Also since surface irregularities can serve as crack or corrosion nucleation sites, roughness is an excellent predictor of a mechanical component's performance. Rough surfaces tend to wear faster and have potentially greater friction coefficients than smooth ones, according to the science of tribology.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature review

The preceding study on polyamide-12 of sharing and intranets is summarized in this chapter, which focuses on that research. It begins by providing an overview of the structure that will be used for the case study that will serve as the primary focus of the research detailed in this thesis. This chapter will also offer a broad understanding of the comparison between the many types of 3D printers that are now in existence. Additionally, this chapter will explain which kind of design applications may be used with 3D printers.

2.2 Introduction

The process of creating three-dimensional solid items from a computer file is referred to as additive manufacturing, which is also known as 3D printing. Despite the fact that Charles Hull pioneered the first 3D printing technology in 1980, this 3D approach has witnessed enormous progress in the previous years. During this time span, it has been utilized extensively in the production of artificial heart pumps, jeweler collections, 3D printed corneas, PGA rocket engines, an Amsterdam steel bridge, and other goods linked to aviation and cuisine. (Shahrubudin et al., 2019)

It all starts with the development of a digital model of the item, which may be done with a programmed known as CAD (Computer Aided Design), a 3D modelling application, or a 3D scanner. This is the first step in the process. When creating a 3D model, 3D scanners make use of a wide range of technologies, some of which include time-of-flight, structured or modulated light, volumetric scanning, and a great number of others. On the other hand, in current day and age, the majority of corporations, such as Microsoft and Google, have allowed their gear to do 3D scanning. One example of this is Microsoft's Kinect. By enhancing the manufacturing process, therefore boosting output rates while also reducing costs. 3D printing has the potential to become one of the primary machines used to simultaneously generate a large number of individual parts. There are many different kinds of 3D printers, design applications, effects, and material testing, as shown in the chart shown in Figure 2-1. Each form of 3D printer has benefits and drawbacks, which are stated in Table **2-1**, Table **2-2** below show the software that can be use in this 3d printing process and all the software is suitable on windows 8, windows 10 and the latest windows 11. Each software has advantage and disadvantage that make user friendly. All the information about the data is get from article that research about each of software.

Table **2-2** and Table **2-3** respectively. At the same time, the demand from customers will have an increasingly significant influence on production. Consumers have a greater voice in the final product and have the ability to request that it be manufactured according to their precise requirements.

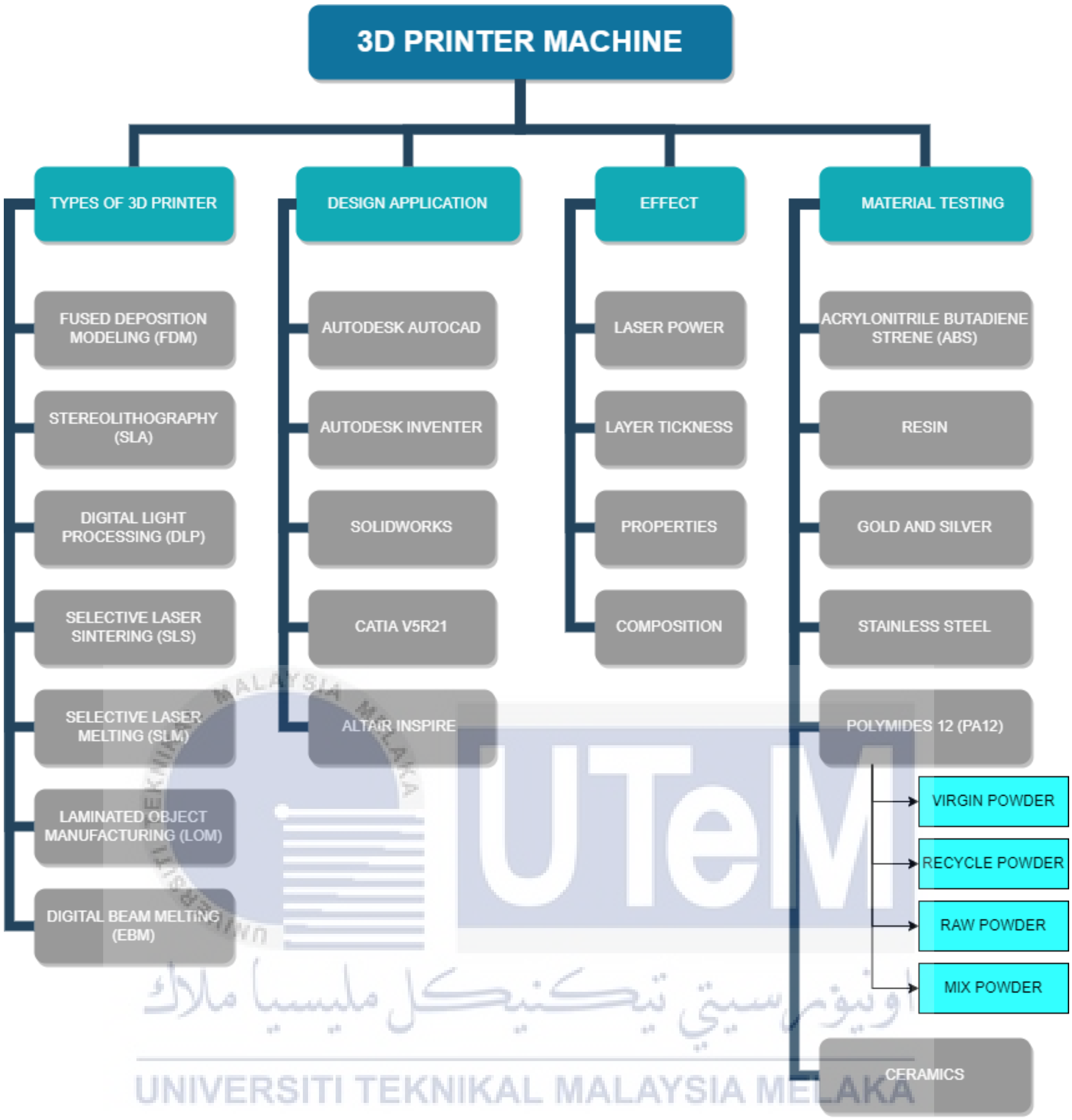

Figure 2-1 k-chart of 3D printer

The use of 3D printing is becoming increasingly widespread, and the technology is helping to increase the modification and manufacture of open source designs in a variety of industries, including agriculture, healthcare, automotive, and aerospace. However, there are a number of disadvantages associated with the employment of 3D printing technology in the manufacturing industry. One of these disadvantages is the fact that it will automatically reduce the amount of production workforce that is used. Additionally, users are able to make a wide variety of objects with the help of the 3D printing technology, including knives, guns, and other potentially dangerous goods. As a consequence of this, the usage of 3D printing should be restricted to a small subset of the population in order to reduce the likelihood that criminals or terrorists would be able to sneak weapons into the country undetected. Those who, on the other hand, are able to get their hands on a blueprint will have the ability to effortlessly counterfeit things. Figure **2-2** show about the Form 2 3D Printer is a stereolithography (SLS) printer since it has a laser spot size of 140 microns, and its laser output is 250 milliwatts. Creating three-dimensional models with the aid of 3D printing technology is as easy as drawing them out on paper and feeding the relevant data into the appropriate equipment. (Shahrubudin et al., 2019)

Figure 2-2 Form lab Form 2 3D Printer

2.3 Comparison Type Of 3d Printer

Table 2-1below show each type of 3D printer that already exist. Each type of 3D print use different of material example like filament, polymer resin and sheet metal. And each 3D printer has advantage and disadvantage that make the each 3D printer has there on benefice. All the information about the data is get from article that research about each 3D printer.