Faculty of Mechanical and Manufacturing Engineering Technology

EXPERIMENTAL STUDY ON MECHANICAL BEHAVIOUR OF FUSED DEPOSITION MODELLING (FDM) PRINTED PARTS

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Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

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MUHAMMAD ZULFIKRI BIN ZULKAFLE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor of Manufacturing Engineering Technology (Product Design) with Honours

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ABSTRAK

Tujuan kajian ini mengenai kesan bebas dari setiap parameter pemprosesan pada sifat mekanik bahagian FDM. Bahan mentah digunakan PLA dan dianalisis dengan menggunakan Rekabentuk Eksperimen dan pengujian tegangan. Objektif projek ini adalah untuk menyiasat setiap parameter pemprosesan ke atas sifat-sifat mekanikal yang dijalankan menggunakan reka bentuk eksperimen Taguchi dan memperoleh sifat-sifat mekanik bagi setiap sampel yang dibuat menggunakan ujian tegangan mengikut piawaian ASTM D638 (Jenis IV). Kaedah untuk menghasilkan spesimen 'Bone Dog' menggambarkan model CAD dengan menggunakan perisian Solidworks, maka spesimen yang dihasilkan menggunakan Pencetak UP Plus 2. Parameter faktor yang menyumbang kepada percubaan ini adalah ketebalan lapisan iaitu 0.2mm, 0.3mm atau 0.4mm, orientasi iaitu 0 °, 45 ° atau 90 °, infill yang padat, longgar atau berongga, dan kelajuan yang baik, normal atau cepat. Ujian tarik adalah teknik utama untuk mendapatkan sifat mekanikal yang berkaitan dengan tekanan dan ketegangan spesimen. Corak pecah tegangan yang diperhatikan dengan menggunakan mikroskop. Perisian Minitab menghasilkan parameter yang dioptimumkan yang ketebalan lapisan adalah 0.4mm, orientasi adalah 90 °, infill longgar dan kelajuan cepat. Hasilnya menunjukkan parameter terbaik yang dilakukan dalam ujian pengesahan yang tegasan tegangan ramalan adalah 44.59MPa. Setelah menjalankan ujian pengesahan mengikut parameter yang dioptimumkan, maka hasil tegangan tegangan untuk ujian pengesahan akan dibandingkan antara ramalan tegangan ramalan. Kesalahan peratusan untuk ujian pengesahan ialah 9.54% berbanding tekanan tegasan ramalan.

ABSTRACT

The aimed of this study on the independent effect of each processing parameter on the mechanical properties of FDM parts. The raw material was used PLA and analyzed by using Design of Experiment and tensile testing. The objectives of this project were to investigate each processing parameter on the mechanical properties conducted using Taguchi's design of experiments and to obtain the mechanical properties of each fabricated sample using a tensile test per ASTM D638 standards (Type IV). The method to produce 'Dog Bone' specimen is drawn the CAD model by using Solidworks software, then the specimen produced using UP Plus 2 Printer. The parameter of factors that contributed to this experiment was the thickness of the layer which is 0.2mm, 0.3mm or 0.4mm, an orientation which is 0°, 45° or 90°, infill which is solid, loose or hollow, and the speed which is fine, normal or fast. Tensile testing is the main technique to get the mechanical properties that were about stress and strain of the specimen. The tensile breaking pattern observed by using a microscope. The Minitab software generated the optimized parameter which was the thickness of a layer is 0.4mm, orientation is 90°, infill is loose and speed is fast. The result shows the best parameters then conducted in the confirmation test which the prediction tensile stress was 44.59MPa. After running the confirmation test according to the optimized parameter, then the result of tensile stress for the confirmation test will be compared between the prediction tensile stress. The percentage error for the confirmation test is 9.54% compared with the prediction tensile stress.

DEDICATION

This thesis is dedicated to my beloved parent, my mother Hajah Zaini Binti Ismail and my father Haji Zulkafle Bin Zainal who always gives support and encouragement during the challenges of my whole university life.

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LIST OF SYMBOLS

μm	-	micrometre
mm	-	millimetre
°	-	degree
°C	-	degree Celsius
cm^3/h	-	centimetre cubic per hour
MPa	-	Mega Pascal
mm/mm	-	millimetre per millimetre
N	-	Newton

LIST OF ABBREVIATIONS

3D	-	3 Dimension
SL	-	stereolithography
UV	-	ultra-violet
SLA	-	StereoLithography Apparatus
AM	-	Additive Manufacturing
FDM	-	Fused Deposition Modelling
ASTM D638	-	Standard Test Method for Tensile Properties of Plastics

CHAPTER 1

INTRODUCTION

1.0 Introduction

This Chapter was provided with the background information of this study and the organization of the theory. The originality of this study is revealed by the information presented in this thesis. The study gives descriptive information: background, statement of problems, goals, scope and structure of thesis.

1.1 Background

In 1987, additive manufacturing first established in 3D Systems with stereolithography (SL), a process which solidifies light-sensitive liquid polymers of the thin layers of ultra-violet (UV) using the layer laser. SLA stands for Stereolithographic Apparatus. The precursor of the once-popular SLA 250 was the SLA-1 machine, the world's largest commercially available AM system. The 3D Systems Viper SLA item substituted the SLA 250 many years earlier.

Additive Manufacturing provides major benefits in the production of the part which provides unrivalled flexibility of design and the ability to produce single or multiple components from a broad spectrum of materials. The technique is regarded as a process of additives rather than a process of subtraction that extracts fabric parts such as milling. 3D Printing, Additive Fabrication, Freeform Fabrication, Fabbing and Additive Layer Manufacture include the other terms used for describing the general process.

In the middle of the 1980s, the early AM process was established as a solution for the rapid development of products. Rapid Prototyping was the practice at this time as it was intended to make three-dimension designs or mock-ups to verify the shape, fit-up and function. As a part of industry and technology, three-dimensional printing, or additive manufacturing, has been around for already more than thirty years as a rapid prototyping technology-fast and cost-effective method for creating prototypes for product development within the industry (3D Printing Industry, 2015). Although it has been available for years, it is only recently that 3D printing technology has found its way on the markets, which helped it to become another mainstream of the century. Since then, the technology is now used in prototyping and distributed manufacturing with applications from architecture to fashion, from aerospace to dental technology, and way beyond.

1.2 Problem Statement

FDM devices have a basic layer-by-layer part to build. In order to support both tasks, the FDM uses a separate nozzle and structural material deposition. The used material is ideally one that is fused and quickly solidified after looking at the previous layer in a pre-selected temperature. It is important to identify the right FDM machine parameters (UP! Plus 2) to produce a component that can comply with the desired specifications. There are a few important parameters for the manufactured part that can affect part specification. For instance, the layer thickness, support angle and orientation axis are such parameters. The combinations of various sets of parameters certainly generate parts with distinct requirements, and so it is essential to examine the appropriate mix of parameters for optimal production.