STUDY ON STRENGTH COMPARISON OF FDM PRINTED ABS MANUFACTURED BY DIFFERENT COMPANIES

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This report is submitted
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DECLARATION

I declare that this project report entitled “Strength Comparison of FDM Printed ABS Manufactured by Different Companies” is the result of my own work except as cited in the references

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother and father

ABSTRACT

Additive Manufacturing (AM) is a technology for printing three-dimensional objects from three-dimensional model data. It has been enhanced to minimise production costs. The most widely used additive manufacturing process is fused deposition modelling, which extrudes models layer by layer using a thermoplastic filament. It is becoming increasingly important and plays a significant role in the manufacturing of multifunctional product nowadays. When selecting the proper material for 3D printing, it is necessary to consider the intended usage of the material. The appropriate material selection is critical to ensuring the product's durability and strength. The goal of this study was to assess the strength of a thermoplastic material chosen for comparison, which is Acrylonitrile Butadiene Styrene (ABS) that is made by various companies. Specimens were manufactured using thermoplastic filament and submitted to tensile and compression tests to see whether different manufacturers have an effect on the strength. All printed specimens were ensured to have the same parameters for printing process to avoid interfering with the testing results. The ABS material's strength was determined by the way each specimen reacted and the highest load that the specimen could withstand during compression and tensile tests. The data indicate that different manufacturers have an effect on the ABS material's strength. The methodologies used in this study are sufficient to demonstrate the strength comparison of ABS material manufactured by various manufacturers.

ABSTRAK

Pembuatan aditif ialah teknologi untuk mencetak objek tiga dimensi daripada data model tiga dimensi. Ia telah dipertingkatkan untuk meminimumkan kos pengeluaran. Proses pembuatan aditif yang paling banyak digunakan ialah pemodelan pemendapan bersatu, yang mencetak model lapisan demi lapisan menggunakan filamen termoplastik. Ia menjadi semakin penting dan memainkan peranan penting dalam pembuatan produk pelbagai fungsi pada masa kini. Apabila memilih bahan yang sesuai untuk percetakan 3D, adalah perlu untuk mempertimbangkan penggunaan bahan yang tepat. Pemilihan bahan yang sesuai adalah penting untuk memastikan ketahanan dan kekuatan produk. Matlamat kajian ini adalah untuk menilai kekuatan bahan termoplastik yang dipilih untuk perbandingan, iaitu Acrylonitrile Butadiene Styrene (ABS) yang dibuat oleh pelbagai syarikat. Spesimen telah dicetak menggunakan filamen termoplastik dan diserahkan kepada ujian tegangan dan mampatan untuk melihat sama ada pengeluar berbeza mempunyai kesan ke atas kekuatan. Spesimen yang dicetak dipastikan mempunyai parameter yang sama bagi setiap spesimen eksperimen untuk mengelakkan gangguan dengan keputusan ujian. Kekuatan bahan ABS ditentukan oleh cara setiap spesimen bertindak balas dan beban tertinggi yang boleh ditahan oleh spesimen semasa ujian mampatan dan tegangan. Data menunjukkan bahawa pengeluar yang berbeza mempunyai kesan ke atas kekuatan bahan ABS. Metodologi yang digunakan dalam kajian ini adalah mencukupi untuk menunjukkan perbandingan kekuatan bahan ABS yang dikeluarkan oleh pelbagai pengeluar.

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LIST OF ABBREVIATIONS

AM	Additive Manufacturing
CAD	Computer-aided Design
FDM	Fused Deposition Modeling
ABS	Acrylonitrile Butadiene Styrene
PLA	Polylactic Acid
3DP	3-Dimensional Printing
LMD	Laser Metal Deposition
ASTM	American Society for Testing and Material
CAM	Computer-aided Manufacturing
DOE	Design of Experiment
NCDS	Nano Composite Deposition
RP	Rapid Prototyping
PP	Polypropylene
PE	Polyethylene
PEEK	Polyether Ether Ketone
PMMA	Poly(methyl methacrylate)
SMP	Shape Memory Polymer
ASCII	American Standard Code for Information Interchange
DCP	Digital Light Processing
CI	Confidence Interval
ISO	International Organization for Standardization
PN-EN	European Standards
FD	Fused Deposition
SFF	Solid Freeform Fabrication
STL	Stereolithography

LIST OF SYMBOLS

α	=	Angle
w	=	Width
mm	=	Millimeters
$°C$	=	Celcius
P	=	Facet vertices
n	=	Floating numbers
v	=	Floating numbers
z	=	Facet's height
T_g	=	Transition temperature
T_m	=	Melting point
T_e	=	Extrusion temperature
in	=	Inches
L_3	=	Total length
L_1	=	Length of parallel edges narrow zone
R	=	Radius
b_2	=	Width of ends
b_1	=	Width of narrow zones
h	=	Thickness
L_0	=	Reference Length
L	=	Length between clamps

CHAPTER 1

INTRODUCTION

1.1 Background

Additive Manufacturing (AM) is the process of printing 3D products out of 3D model data. Additive Manufacturing processes take the information from a computer-aided design (CAD) file that is later translated to a stereolithography (STL) file. Each layer that will be printed containing the information of the CAD drawing that is approximated by triangles and sliced in this process. The Additive Manufacturing (AM) has been advanced for reducing production costs.

Amongst the numerous 3D printing methods, the utmost prominent AM technology in today's global is Fused Deposition Modeling (FDM). It has a wider array of people who are interested in it because of its reliability, wide variety of useable materials, safety, and production simplicity, as well as cheaper equipment costs and lower process temperatures. For polymer processing, FDM is the most widely used method. It may be used with a wide range of thermoplastic materials. Many different materials have been utilised or produced as a result of investigating materials for additive technologies, including countless types of thermoplastics, metals, ceramics, composites, biodegradable polymers, short fibre composites, polymer-metal mixture materials, and so on. On the market, there are many different materials to choose from, as well as a significant figure of different FDM substance company brands. In choosing the material, it is crucial because it contributes to the accomplishment of an excellent 3D printing outcome. This is especially important when evaluating price disparities for the same commodity.

Acrylonitrile butadiene styrene (ABS) is a well-known selection for filament in 3D printing, it is a three-monomer amorphous polymer consisting of acrylonitrile, butadiene, and styrene. ABS model components are very robust, have great dimensional stability, are simple to manufacture, are chemical resistant, and are inexpensive. It also has fascinating modelling characteristics and a broad range of colours. ABS filaments are available in 1.75 mm or 3 mm diameters and a variety of colours in FDM.

According to Adi Pandžić et al. (2020), although every single one PLA specimens were 3D printed in the similar settings, contrast in the mechanical behaviour content from different manufacturers can be seen. The strength values stated by manufacturers also vary from the findings shown in the paper. There is a possibility that this may happen for other materials. Hence, the objective of this project is to study the strength comparison of FDM printed ABS manufactured by multiple companies.

1.2 Problem Statement

There are currently many different manufacturers for the identical FDM material where the price difference could go up to 50%. According to Adi Pandžić et al. (2020) study, PLA materials from different companies may have different tensile strengths. The findings revealed that even though the material is the same, the tensile properties of the same material vary between manufacturers. This could happen with other similar materials. This project will focus on strength comparison of FDM printed ABS from different manufacturers. The results of the research will be beneficial for consumers to choose best ABS material with low cost and offering the greatest strength.

1.3 Objective

The objective of this project are as follows:

1. To compare the difference in tensile strength properties of ABS FDM printed material from different manufacturers (maximum force, tensile strength, yield strength, Young Modulus, stress strain diagram).
2. To analyse the compressive strength of ABS FDM printed material from various manufacturers.

1.4 Scope of Project

The scopes of this project are:

1. Only results of the strength of ABS materials are presented in this report.
2. Design the test specimen using CATIA V5.
3. The strength comparison of the specimens is measured by tensile test and compressive test only.
4. Creating the specimen using Creality Ender-6 FDM 3D Printer.

1.5 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature review

   Journals, articles or any materials related to this will be analysed.

2. Measurement

Surveying the correct measurement and dimension for cylinder specimen required to test compressive strength. Making sure all specimen for different manufacturers is the same in size and dimensions.

3. Design

   Designing the shape of the specimens using CATIA V5. Ensuring all the dimensions are correct and identical for each specimen.

4. Create

   Build the cylinder specimen using Creality Ender-6 FDM 3D Printer. Ensuring all the specimen using the same printer and the same printing parameters to avoid the possible interferences with the result.

5. Testing

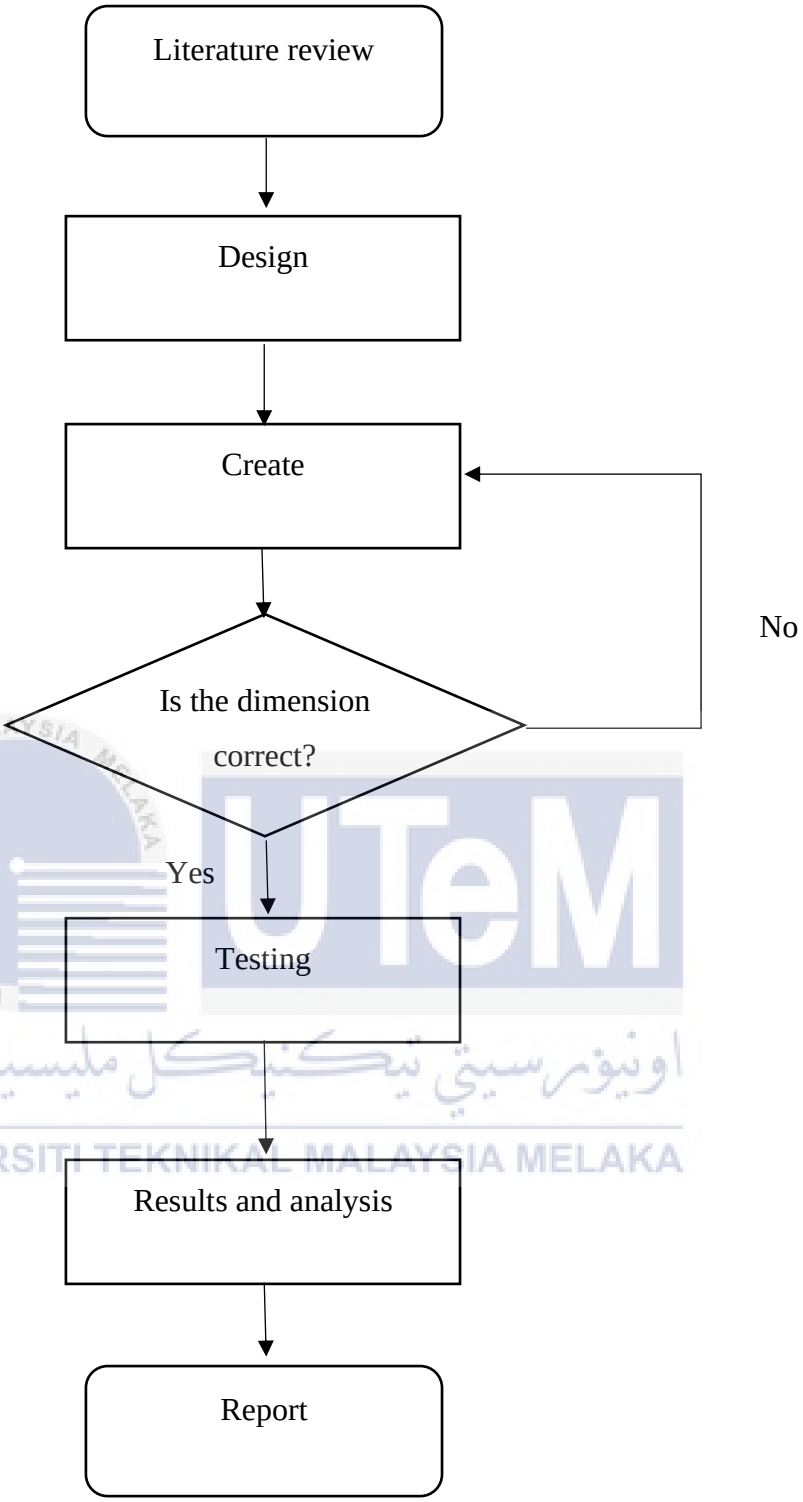
   Experimental study of the compressive strength with the specimens.

6. Results and analysis

   All results are collected in a suitable manner. Analysis will be presented on how every specimen from particular manufacturer withstand the compressive testing until failure to determine their strength.

7. Report writing

   A report on this study will be written at the end of the project.



Flowchart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter goes over a few key components that involve with Fused Deposition Modelling (FDM) and materials used for 3D printing. PLA, PETG, and ABS are just a few of the various materials available for FDM printing. ABS is one of the most often utilised materials in the industry for 3D printing these days due to a lot of advantages such as great heat resistance and lightweight. Given the large number of companies out there making the same material and each claiming to have the best product, consumers are having difficulty deciding which brand is the most durable. The goal of the project is for studying the strength comparison of FDM printed ABS manufactured by different companies. Several ABS specimens from a manufacturer will be printed and their strength will be tested using compressive test and tensile strength test. At the end of this project, the ABS material strength from various manufacturers can be compared to determine which brand is the best and provides the most value for money.

The failure of each specimen from each manufacturer can be detected by the strength testing. The point of failure, as well as the amount of compression and tension that a specimen can bear, will be determined. To eliminate errors and interference with the test findings, each specimen prepared for the test must have the same dimension. ABS material strength from various manufacturers will be compared and analysed.

2.2 Additive Manufacturing

Additive manufacturing (AM) is manufacture producing name for 3D printing, a computer-controlled process that produces three dimensional objects by deposition of substance, commonly in layers. AM processes also have been studied, and some have even been commercialised. Stereolithography (SLA), Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Laminated Objective Manufacturing (LOM), Three-Dimensional Printing (3DP), and Laser Metal Deposition (LMD) are just a few examples of AM [2]. Information is taken from a computer-aided design (CAD) file and translated to a stereolithography (STL) file in additive manufacturing processes. The drawing created in CAD software is approximated by triangles and sliced to include the details for each layer that will be printed in this process. AM technologies have the advantage of being able to create items with geometric and material complexities that would be impossible to achieve with subtractive manufacturing methods.

The ASTM F42 committee grouped the AM processes into seven categories in an effort to standardise terminology. The method of material deposition, the energy source used, and the state of the construction material used all differ from one another (wire feedstock, liquid, powder or sheets). The following is a list of these processes:

1) Binder jetting: To combine powder materials, a liquid bonding agent is placed selectively.
2) Directed energy deposition: Focused thermal energy (e.g., laser, electron beam, or plasma arc) is used to fuse materials by melting as they are being deposited
3) Material extrusion: Material is selectively dispensed through a nozzle or orifice.
4) Material jetting: Droplets of build material are selectively deposited.
5) Powder bed fusion: Thermal energy selectively fuses regions of a powder bed.
6) Sheet lamination: Sheet materials are bonded to form an object.

7) Vat photopolymerization: Liquid photopolymer in a vat is selectively cured by light-activated polymerization.

2.3 Fused Deposition Modeling

Fused Deposition Modeling (FDM) is 3D printing process that uses a continuous filament of a thermoplastic material. Software that processes an STL file (stereolithography file format) is needed for FDM technology. A model must then be sliced with another programme for the build operation. Support systems can be created if necessary. The model is created by extruding thermoplastic material that solidifies upon exiting the nozzle in layers. A coil of plastic filament is unwound, and the flow is controlled by an extrusion nozzle. Worm-drive regulates the pace of filament insertion into the nozzle. To melt the material, the nozzle is heated. A numerically operated mechanism allows it to travel in both horizontal and vertical directions. A computer-aided manufacturing (CAM) software programme controls the nozzle, and the component is shaped from the bottom up, one layer at a time. Extrusion head movement is regulated by stepper motors. The mechanism employs an X-Y-Z rectilinear movement.

FDM process is extremely versatile because it allows minor overhangs on the lower layers. One of certain limitations of FDM is it cannot manufacture undercuts without the use of support content. Variety of FDM materials available, including ABS and PLA, that have various difference that can be comparable between strength and temperature properties [9].

2.4 FDM Parameter

The qualities of produced items are determined by numerous printing conditions that are set during fabrication process. From a research done, FDM process parameters affect the