UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STATISTICAL ANALYSIS OF THE RAPID PROTOTYPING 3D PRINTER PROCESS TO DETERMINE ACCURACY

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

by

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DECLARATION

I hereby declare that this report entitled **"Statistical Analysis of the Rapid Prototyping 3D Printer process To Determine Accuracy"** is the result of my own research except as cited in the references.

Signature	:	………………………………
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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follow:

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ABSTRACT

This study on "Statistical Analysis of the Rapid Prototyping 3D Printer Process to Determine Accuracy" was done in order to achieve its three main objectives which is first, to study the development of 3D printer, technology and process. Secondly, to study the parameters' needed in the process of producing prototype and finally was to make detail analysis of all the parameters in order to get highest accuracy and quality. As for the Projek Sarjana Muda 1 (PSM1), the main objective need to be achieved in this PSM 1 was to complete the chapter for Introduction, Literature Review and Methodology. In the introduction chapter, it will cover the general overview and basic information on the research done. This chapter includes the study objectives, problem statements and scope of the study. In the second chapter which is the literature review, this chapter shows all the informations, definitions and past study that is related to the research. Sources of information in this chapter was based from past research journals, related articles, books and webpages from internet. All the information gathered was purely based on previous study done by experts in this field of rapid prototyping, design and 3D printing. The final chapter of the PSM 1 is the methodology, in this chapter it include the process flow chart from the early stage of the research till its final step of the project. It also included the details of the flow chart for easier understanding of the chart. Then, a design was made for the experiment and the shape chosen was a cylinder. During the printing process, data for layer thickness and build-up direction were taken and further data on the cylinder's length, diameter and surface finish were measured for the analysis. Finally, a statictical analysis were done to determine which paramaters affect the accuracy of the printer the most.

ABSTRAK

Kajian ini "Analisis Statistik untuk Rapid Prototyping Pencetak 3 Dimensi bagi Mendapatkan Ketepatan" dijalankan agar mencapai objektif utamanya iaitu, mengkaji perkembangan pencetak 3D, teknologinya serta proses-proses yang terlibat. Keduanya, mengkaji parameter-parameter yang diperlukan dalam proses penghasilan sesuatu prototaip dan akhirnya menjalankan analisis lengkap untuk parameter-parameter bagi memperoleh ketepatan dan kualiti terbaik. Bagi Projek Sarjana Muda 1 (PSM 1), matlamat utamanya adalah untuk menyempurnakan topic pengenalan, ulasan pembacaan dan kaedah kajian. Di dalam topik pengenalan, ia akan membincangkan mengenai informasi umum mengenai kajian ini. Selain itu, ia turut membincangkan objektif kajian, pernyataan masalah dan skop kajian. Topik kedua pula menunjukkan semua maklumat, definisi dan kajian-kajian terdahulu yang berkaitan dengan rapid prototyping, pencetak 3D dan rekabentuk. Sumber-sumber maklumat diperoleh dari jurnal-jurnal berkaitan, artikel, buku dan laman web. Topik terakhir mengenai metodologi pula membincangkan carta alir proses-proses terlibat dalam melaksanakan PSM 1. Ini adalah bagi memudahkan kerja-kerja perlaksanaan PSM 2. Kerja-kerja merekabentuk specimen dijalankan bagi tujuan eksperimen dan pengumpulan data. Bentuk yang dipilih bagi eksperimen ini adalah bentuk silinder. Semasa proses mencetak dijalankan, data-data dikumpul dan juga selepas cetakan dibuat. Data - data seperti tebal lapisan, panjang, diameter dan ukuran pemukaan diambil bagi tujuan analisis. Akhir sekali, satu analisis statistik dijalankan bagi mancapai matlamat ujikaji iaitu bagi mendapatkan ketepatan yang mempengaruhi operasi pencetak 3D.

DEDICATION

Special dedication to my family especially my parent, friends and last but not least my two supervisors. Thank you for all of your supports.

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LIST OF ABBREVIATIONS AND SYMBOLS

2D	-	Two Dimension
3D	-	Three Dimension
3DP	-	Three Dimensional Printing
σ	-	Standard Deviation
ABS	-	Acrylonitrile Butadiene Styrene
ANOVA	-	Analysis of Variance
BDP	-	Binary Deflection Printing
BO	-	Border Overcure
CAD	-	Computer Aided Design
CAD/CAM	-	Computer Aided Design/ Computer Aided Manufacturing
CATIA	-	Computer Aided Three Dimensional Interactive Application
EBM	-	Electron Beam Melting
FDM	-	Fused Deposition Modeling
GF	-	Geometric Features
HO	-	Hatch Overcure
HR	-	High Resolution
HS	-	Hatch Spacing
IA	-	Infiltrating Agent

J-P	-	Jetted- Photopolymer
LOM	-	Laminated Object Manufacturing
LT	-	Layer Thickness
MIT	-	Massachussets Institute of Technology
MM	-	Single Jet-Inkjet
MU	-	Material Used
ND	-	Nominal Dimension
NR	-	Normal Resolution
PC	-	Polycarbonate
PDP	-	Proportional Deflection Printing
PP	-	Polypropylene
PS	-	Polystyrene
PSM	-	Projek Sarjana Muda
PT	-	Post Treatment
PVC	-	Poly Vinyl Chloride
RP	-	Rapid Prototyping
RTV	-	Room Temperature Vulcanization
TSF	-	Topography Shape Formation
SLS	-	Selective Laser Sintering
SL/SLA	-	Stereolithography

S/N RATIOS	-	Signal to Noise Ratios
WT	-	Wall Thickness
X_{im}	-	Single Measured Dimension
X_{iCAD}	-	Single CAD Dimension

CHAPTER 1

INTRODUCTION

This chapter explains about the research background, objectives of the study, problem statements for the study and finally, scope of the research. This will hopefully give simple guide or introduction about the study about the "Statistical Analysis of the Rapid Prototyping 3D printer Process to Determine Accuracy".

1.1 Research Background

3D printing is a category of rapid prototyping technology. A three dimensional object is created by layering and connecting successive cross sections of material. 3D printers are generally faster, more affordable and easier to use than other additive fabrication technologies.

Three-dimensional models are being increasingly used as prototypes in various areas of manufacturing, research and education. They are especially useful in the evaluation of elements typical of mechanical design, but are also important in architecture, medicine, arts, etc. These models can be developed using various methods, such as mass modeling, surface planification, and rapid prototyping (RP) with removal or addition of material based on a CAD/CAM platform. This latter approach was employed in the present paper. Complex solids are formed through the association of elementary solids such as spheres, prisms, cylinders, torus, etc., and then rapid prototyping is applied involving a slicing process. A virtual model based on a CAD platform allows the determination of paths for each sliced level. These are translated into numerical control codes, and fed to a milling process of a blank, allowing the manufacturing of a 3D model [1].

3D printing is optimized for speed, low cost, and ease-of-use, making it suitable for visualizing during the conceptual stages of engineering design when dimensional accuracy and mechanical strength of prototypes are less important.

1.2 Problem Statement

3D Printer is the most modern among other rapid prototyping compare to Stereolithography, Fused Deposition Modeling, Selective Laser Sintering and others. It has evolved from the use of traditional woodblock printing to the latest and most advance three dimensional printing (3DP). As normally in any new technology produced or developed, there will be some setback in which will affect the performance of the product in this the 3D printer. Therefore in this study, a research will be done in order to determine the factors influences the 3D printer. The study will try to find out the parameters and an analysis will be done. This is because, the problem occurs with the 3D printer is the machine accuracy. Furthermore, in manufacturing of a product; accuracy of the product produced is important such as its dimension, shape and design.

The parameters that may influence the accuracy of the 3DP were; layer thickness, hatch overcure, hatch spacing, border overcure, fill spacing and fill cure depth [1]. From these factors, the statistical analysis on how to improve the 3DP accuracy can be done. Therefore, the need for designing a product and producing it with the 3DP is important in order to improve the machine accuracy.

Other than that there are also factor that could disrupt the accuracy of the 3DP. They were; the material used, nominal dimension, build orientation, geometric features and their topology, wall thickness, post treatment procedures and infiltrating agent [3].