STUDY ON DESIGN FOR MANUFACTURING OF BENCHMARKING DESIGN USING FUSED DEPOSITION MODELING AN ENTRY LEVEL 3D PRINTER

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

……………………………
(Project Supervisor)

ABSTRAK

"Additive Manufacturing" merujuk kepada kelas baru proses pengilangan yang membina bahagian fizikal dengan cara lapisan demi lapisan. Walaupun pelbagai proses ini boleh didapati secara komersial yang berbeza antara satu sama lain dengan cara yang mereka membina sebahagian, Proses ini masih dalam peringkat awal pengkomersilan serta mempersembahkannya potensi yang tinggi untuk penyelidikan dan pembangunan. Oleh itu, dalam usaha untuk meningkatkan keupayaan teknikal (iaitu dimensi ketepatan) reka bentuk tanda aras yang berbeza dengan melaraskan tetapan parameter. Sebahagian penanda aras geometri telah dicadangkan, yang direka-reka dan untuk penilaian prestasi oleh prototaip pantas mesin sumber terbuka atau proses. Bahagian geometri penanda aras menggabungkan bentuk dan ciri-ciri bahagian penanda aras yang lebih dikenali utama. Bahagian-bahagian yang dihasilkan harus fabrikasi sesuai cukup pada mesin *"Rapid Prototyping"* biasa. Dalam kajian ini, penggunaan bahagian penanda aras ditunjukkan menggunakan konsep yang agak Terlakur Model *"Fused Deposition Modeling"*. Ini boleh menunjukkan keupayaan sebahagian penanda aras telah dicetak dengan menggunakan 3D pencetak peringkat kemasukan akan boleh dicapai ciri geometri dan ketepatan sama seperti model "Computer Aided Drawing".

ABSTRACT

Additive Manufacturing (AM) refers to a new class of manufacturing processes that build physical parts in a layer-by-layer manner. Even though a variety of AM processes are now commercially available which differ from each other in the way they build a part , AM processes are still in their early stages of commercialization and thus present a high potential for research and development. Therefore, in order to improve the technical capabilities (i.e. dimension accuracy) of different benchmarking design by adjust the parameter setting. A geometric benchmark part is proposed, designed and fabricate for performance evaluation of Rapid Prototyping (RP) open source machine or process. The benchmark geometric part incorporates key shapes and features of better known benchmark parts. The parts produced should be suitable fabrication enough on a typical RP machines. In this study, the application of the benchmark part is demonstrated using relatively Fused Deposition Modeling (FDM) concept. This is can show the ability of the benchmark part were printed by using 3D printer entry level will achievable geometric features and accuracy same as the CAD model.

DEDICATION

Alhamdulillah first and foremost, I would like to credit this project to almighty god, Allah S.W.T for keep me level headed throughout this process.

This project is also dedicated to my beloved and wonderful parents Mr Mohd Basir bin Musa and Mrs Saidatul Fadzilah bt Padan, who encourage me mentally, physically, and spiritually to keep moving throughout the process and inspire me to break the border of true limitation and reach for my definite set of purpose. In additional huge credit for their sacrifices, financial support through the thick and thin and to my siblings for the extra push of encouragement. In every dark cloud there's always a silver lining.

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AM	-	Additive Manufacturing
RP	-	Rapid Prototyping
FDM	-	Fused Deposition Modeling
CMM	-	Coordinate Measuring Machine
ABS	-	Acrylonitrile Butadiene Styrene

CHAPTER 1
INTRODUCTION

1.1 Background

Demand for the complexity of products increases, Rapid Prototyping (RP) technologies are gaining ever greater importance technologies, and industrial demand is driving manufacturers to improve the specifications of RP machines. Nowadays, prototypes are often created with additive layer manufacturing technology, also known as 3D printing. Additive Manufacturing (AM) is a group of procedures in which a numerical portrayal of a protest is utilized to create the question one layer at any given moment. The AM forms are recognized by the manufacture materials and means by which the layers are combined. Fused Deposition Modeling (FDM) is a case of an AM procedure in view of the intra and interlayer chemical bonding coming about because of the extrusion of molten Acrylonitrile Butadiene Styrene (ABS) thermoplastic from a heated nozzle.

Fused Deposition Modelling (FDM) are usually used in the industrial because it is a standout amongst the most utilized Additive Manufacturing (AM) systems that have capacity to fabricate exceptionally complex geometries shapes. Moreover, in this systems likewise can play out the dimensional accuracy, surface roughness, mechanical strength or more all usefulness of assembled parts are reliant on many process factors and their settings. That means, the setting of the machine is actually important to produce the best product with good design. The main focus of this study is to determine the parameters setting used in Fused Deposition Modelling (FDM) that related on the part quality and properties of the products.

During conducting this investigation, the machine used is producing the benchmarking design would be 3D printer machine. The models of this 3D printer machine known as UP Plus which an open-source fused deposition modeling 3D printer. This machine have a capability to creating many of its own parts, which are usually printed in Acrylonitrile Butadiene Styrene (ABS) filament.

1.2 Problem Statement

Since the middle of the last decade, open source and relatively inexpensive AM systems based on Fused Deposition Modeling (FDM) have become available. These systems include the Fab@Home 3D printer (E. Malone and H. Lipson, 2007), the RepRap project (E. Sells et al., 2009), and most recently, the CupCake CNC and Thing-O-Matic 3D printers by MakerBot Inc (MakerBot Industries." [Online], 2011). The Fab@Home 3D printer was originally designed with a non-heated syringe based extrusion system with thermosetting polymer for the build material, but can now be configured to extrude melted ABS plastic like the RepRap and MakerBot systems. In this study, focusing to RepRap project because of the objective of the RepRap project was to develop an open source 3D printer that could be used to fabricate its own components ("self-replicate").

Prusa i3 is an open-source 3D printer Fused Deposition Modelling (FDM). It is part of the RepRap project, it is the most used 3D printer in the world. The Prusa i3 is comparable low cost and ease of construction and modification has made it popular in education and with hobbyists and professionals. Due to the printer being open source there have been many variants produced by companies and individuals worldwide, and like many other RepRap Prusa i3 is the printers capable of printing some of its own parts. The RepRap Prusa i3 project, are more so focused on the fabrication of generic objects and have received quite a bit of general media attention, but has received limited evaluation and application in the literature. According Pei et al., (2011), recently studied the three previously mentioned open source AM systems and evaluated the capacity of a RepRap based system (Rapman) to fabricate geometrically complex parts. However, there several open-source 3D printer, one of them is UP Plus 2 which are can perform same as others. But, there as have some setting already fixed and cannot changed at all.

According Dr Muhammad Fahad and Dr Neil Hopkinson, (2013), A benchmarking part is an important aspect of evaluating the performance characteristics of various AM processes. Although, many creators/analysts have proposed different plans of benchmarking parts for AM forms, none of these parts thoroughly incorporated every one of the highlights important to build up the coveted exactness or repeatability related parameters.

Therefore, the result will give the AM people group, to the creators' information, the principal benchmarking assessment of an open source FDM AM framework. Be that as it may, it additionally can grow the mindfulness and utilization of such frameworks as an innovative work stage in the proceeded with investigation of FDM process in getting changes and applications. In order to obtain an accurate dimension is an important criteria to produce a good design. Good design means design that meet customer’s need and customer satisfaction improved.

1.3 Objective of the Project

The objective of this project is to improve the manufacturability of 3d printed part by using Fused Deposition Modelling (FDM). This objective can be achieve with following specific goals:

i. To study the evaluation on design for manufacturing of benchmarking design.
ii. To investigate an accuracy dimension of the part on different benchmarking design by using CAD,Cube Pro 3D Printer and Up Plus 3D Printer.
iii. To compare the qualitative of dimensional accuracy by using Cube Pro and Up Plus 2 3D Printer.

1.4 Scope of the Project

The scope for this project is specifically design three different types of benchmarking design by using Solid-Works software. The three types of benchmarking design consist of simple, medium and difficult of the design. In order to design the new benchmarking design, several review previous of benchmarking part model in the literature used to evaluate AM systems. Data collection form the sources will be used as references. Print the part model as the references provided and find the dimension on the part by using geo-magic qualify software. In order to find the dimension each of the part, scan the part by using scanner and transfer it into geo-magic qualify software. In this way, it can provide deviation on certain part that chosen and obtain the accuracy dimension of the part model. All three benchmarking design will be print out by using two different machine which is UP Plus 2 and CubePro 3D printer. Thus, purpose of the finding is to compare which one can perform perfectly on their quality of dimension. Besides, the material required to produce the benchmarking design by using 3D printed is Acrylonitrile Butadiene Styrene (ABS) filament. This project will be proceeding on simulation the benchmarking design by using 3D printed machine known as UP Plus 2 which an open-source 3D printer. The benchmarking design size is limitation form (90mm x 90mm x 105mm).

CHAPTER 2
LITERATURE REVIEW

While the first chapter of the research describes background of the project, objectives, problem statement and the scope, this chapter proceeds with referenced review from the relevant literature. Generally, this chapter contains a literature review on 3D printer machine, which includes the Rapid Prototyping (RP), Fused Deposition Modeling (FDM) and the parameter setting. During this research, sources of information were obtained from secondary sources which are books, journals, reports and electronic-media publications. The primary objective of this review is aiming at searching the current status and history of 3D printer. Also study regarding the optimization of parameter setting by used Fused Deposition Modeling (FDM).

2.1 Rapid Prototyping Technology

Rapid Prototyping (RP) is a techniques used to create a three-dimensional model of a part or product (Brenda Cole, 2014). Besides, it is an automatic construction of physical objects using solid freeform fabrication. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology. The first technique for Rapid Prototyping (RP) became available in the late 1980s and were used to produce models and prototype parts. Nowadays, they are used the same concept for a wider range of applications and even used to manufacture production quality parts in relatively small numbers. Some sculptors use the technology to produce a complex shapes for fine arts exhibitions. One of the most commonly used technologies is Fused Deposition Modeling (FDM).

The main advantages of this technology is a good variety of materials available, easy material change, low maintenance costs, quick production of thin parts, a tolerance equal to ±0.1 mm. Overall, no need for supervision, no toxic materials, very compact size, low temperature operation. The main disadvantages are that it leaves a seam line between layers, the material tends to bump up, supports are required, there is axial weakness perpendicularly, a larger area of slices requires longer building times, and temperature fluctuations during production could lead to delamination, and high surface roughness. In particular, poor surface finish affects the function of RP parts, depending on the geometry of the enclosing surface, the building strategy, layer thickness and orientation of the part; this drawback may outweigh the advantages of RP parts (Durgun, I. and Ertan, R. ,2014).

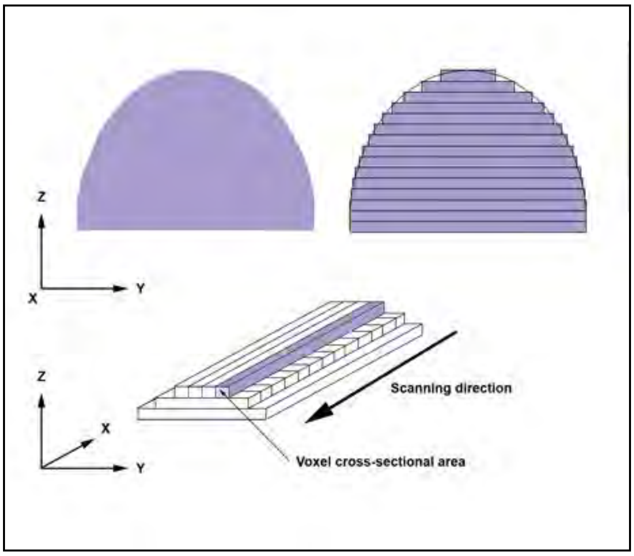

Figure 2.1: 3D Model Slicing
(Source: <http://coho3d.com/?page_id=2>19/03/17)

2.2 Fused Deposition Modeling (FDM)

In additive manufacturing technology the commonly used for modeling, prototyping, and production applications is Fused Deposition Modeling (FDM) techniques. Besides, it is one of the techniques used for 3D printing. FDM works on an "additive" principle by laying down material in layer by layer with a plastic filament or metal wire is unwound from a coil and supplies material to produce a benchmarking design.