"I admit that I have read this report and I found that it is suffice from the aspect of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design & Innovation)"

Signature :

Supervisor : HAMBALI BIN BOEJANG

Date : 8/6/07.

A CASE STUDY OF RAPID PROTOTYPING TECHNOLOGIES

MOHD ZUHRI BIN MOHAMED YUSOFF

A project report is submitted to the Faculty of Mechanical Engineering in partial
fulfillment of the requirements for the award of the degree of
Bachelor of Mechanical Engineering
(Design & Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2007

"I admit this report is done all by myself except statement that I have already stated on each one of them"

Signature : ____________________

Author : MOHD ZUHRI BIN MOHAMED YUSOFF

Date : 08/05/07

To all my family especially my beloved parent, Mr. MOHAMED YUSOFF BIN MOHD NOOR and Madam SURIAH BTE ABDUL RAHMAN, to my supervisor Mr. HAMBALI BIN BOEJANG, all lecturers and all my friends.

Thank you for the motivation and full support

ACKNOWLEDGEMENT

First of all, alhamdulillah and syukran to ALLAH S.W.T as I had successfully complete my final year project and finished the report on time.

I wish to acknowledge with thanks to Universiti Teknikal Malaysia Melaka (UTeM) for giving me such a great opportunity to undergo my study on these course, Mechanical Engineering (Design & Innovation).

My thanks also to my supervisor, Mr. Hambali Boejang for his good advice and also without fail has given me guidance and verification of all project and report. I would also like to express thanks to all my lecturers and technician teams from the Faculty of Mechanical Engineering and Faculty of Manufacturing Engineering for their critics, guidance, opinion, advice and ideas during the final year project period.

I am most grateful for helps and supports from all the BMCD courses mates for their guidance, knowledge exchange and skill. It would be difficult for me to complete my final year project without them. Their kindness will never be forgotten. Beside that, I would also like to thanks to all UTeM students who are helping me directly or indirectly.

Last but not least, my thanks to my parents, family and all my friends for all their great support.

ABSTRACT

This report covers the final year project undertaken by the student in Universiti Teknikal Malaysia Melaka (UTeM). This report describe about a project titled ***"A Case Study Of Rapid Prototyping Technologies"***. The purpose of this project is to compare and evaluate the two types of rapid prototyping technologies machines which are Fused Deposition Modeling (FDM) Prodigy Plus and Three Dimensional Printing (3D Printer) Zcorp. The two types of rapid prototyping machines will be compare and evaluate in terms of dimensional accuracy, build time process and surface finish. This report is divided into six (6) chapters. The first (1) chapter presents the introduction of the project. The second (2) chapter presents the literature review on the rapid prototyping technologies. The third (3) chapter describe the methodology on how this project will be done. In fourth (4) chapter is the experimental work on how the experimental being done to come out the results. Next is chapter five (5), this chapter is where the result had been carry out and the discssusion of the result. The last chapter is chapter six (6) which contain the conclusion of this project.

ABSTRAK

Laporan ini meliputi projek tahun akhir yang di ambil oleh pelajar di Universiti Teknikal Malaysia Melaka (UTeM). Laporan ini menerangkan tentang projek ***"A Case Study Of Rapid Prototyping Technologies"***. Projek ini dijalankan untuk membanding dan menilai dua jenis mesin teknologi prototaip pantas iaitu Fused Deposition Modeling (FDM) Prodigy Plus dan Three Dimensional Printing (3D Printer) Zcorp. Kedua-dua mesin ini akan di banding dan di nilai dari segi ketepatan dimensi, masa pembinaan proses dan hasil permukaan. Laporan ini terbahagi kepada enam (6) bahagian. Bahagian yang pertama (1) mengandungi pengenalan projek. Bahagian kedua (2) merujuk kepada kajian literature ke atas teknologi prototaip pantas. Bahagian ketiga (3) merujuk kepada kaedah bagaimana projek ini akan di jalankan. Dalam bahagian keempat (4) adalah tentang cara menjalankan mesin prototaip pantas dalam menghasilkan keputusan. Seterusnya adalah bahagian kelima (5) di mana keputusan yang diperolehi serta perbincangan mengenainya. Bahagian terakhir adalah bahagian keenam (6) yang mengandungi kesimpulan yang di buat berdasarkan projek ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	Three Dimension
3D Printer/3DP	Three Dimensional Printing
ABS	Acrylonitrile Butadiene Styrene plastic
BASS	Break-Away Support System
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CMM	Coordinate Measuring Machine
FDM	Fused Deposition Modeling
GPS	Geometrical Product Specifications
ISO	International Standard Organization
LOM	Laminated Object Manufacturing
MABS	Methy Methacrylate ABS
MJM	Multi Jet Modeling
RP	Rapid Prototyping
SLA	Stereolithography
SLS	Selection Laser Sintering
SOP	Standard of Procedure
STL	Standard Triangulation Language

LIST OF APPENDIXES

CHAPTER 1

INTRODUCTION

1.1 Background of the Project

Rapid prototyping (RP) was first introduced to the market in 1987, after it was developed with the help of stereolithography. Today, rapid prototyping is also known as solid freeform fabrication, three dimensional printing, freeform fabrication, and additive fabrication [1]. The manufacturing process of rapid prototyping can produce automatic construction of physical models with three dimensional (3D) printers, stereolithography machines, laser sintering systems and other types of RP machines. A variety of rapid prototyping technologies makes a different of dimensional accuracy, built time and surface finish.

The project of "A Case Study of Rapid Prototyping Technologies" is about comparison and evaluation of rapid prototyping technologies from the two types of machines. This project mention about the two types of rapid prototyping machines which is Fused Deposition Modeling (FDM) – Prodigy Plus and Three Dimensional Printing (3D Printer) - ZCorp. A suitable benchmark test model can be designed for the comparison and evaluation of rapid prototyping technologies and enable to obtain helpful data for the analysis result.

1.2 Scope of Project

This project can be defined as an assessment on the two types of rapid prototyping (RP) machines. These selected RP technologies will be assessed in terms of dimensional accuracy, surface finish and built time processes.

1.3 Aim

The aim of this project is to assess RP technologies which are FDM – Prodigy Plus and 3D Printer – ZCorp in terms of dimensional, surface finish and built time processes. This project also aims to make a comparison between the two types of machines.

1.4 Objectives

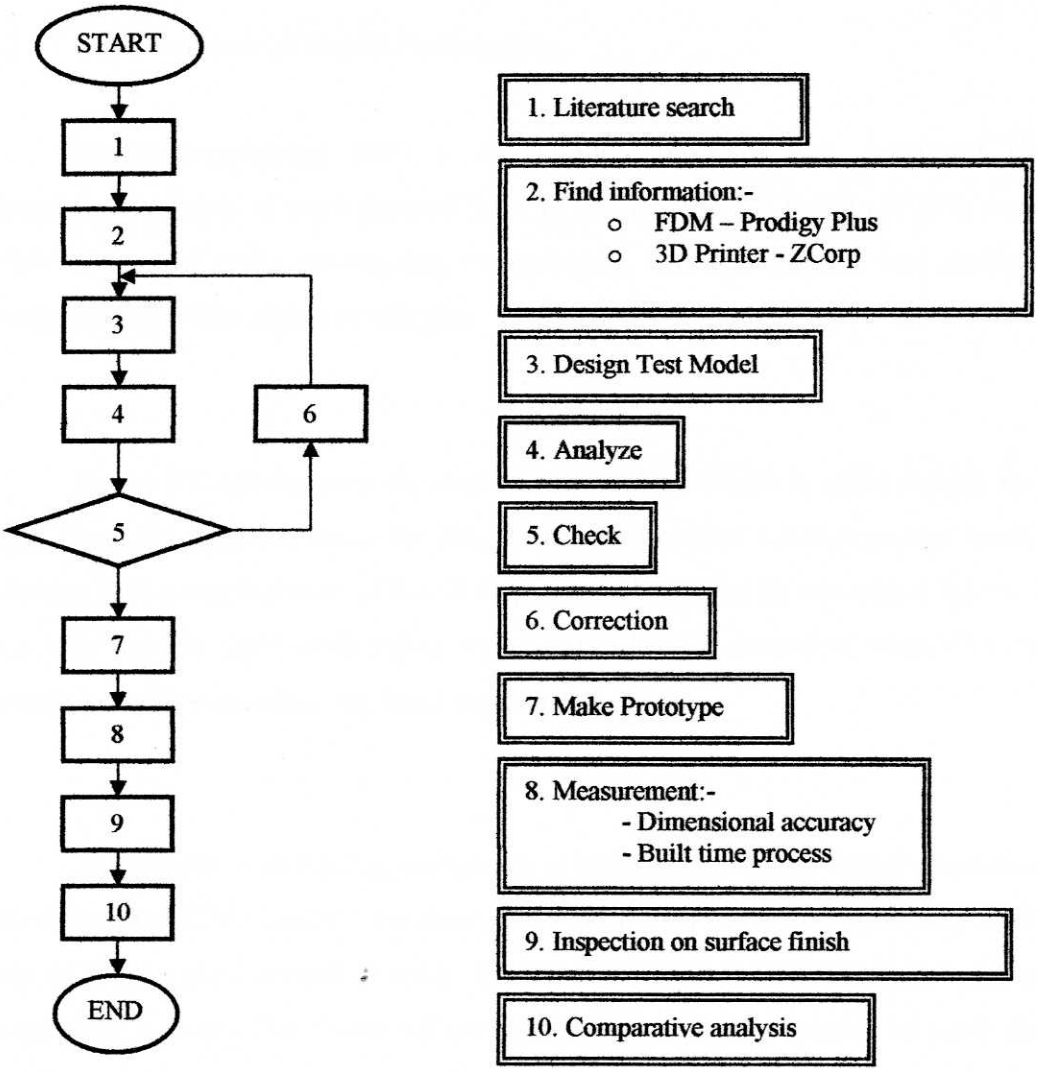
The main objectives of this project are:

- To do literature review
- To design and develop a test model
- To measure the accuracy of the test model
- To measure the pre-processing, built time and post-processing of the machine.
- To study the surface finish of test model and capability of the machine.
- To analyze the result
- To do a comparison

1.5 Problem Statement

The rapid prototyping machines in Universiti Teknikal Malaysia Melaka (UTeM) are not being commercialized to the students. Besides students do not know the capability of the rapid prototyping machines which are FDM Prodigy Plus and ZCorp 3D Printer in terms of the dimensional accuracy, built time and surface finish.

1.6 Project Process Flow-Chart



CHAPTER 2

LITERATURE REVIEW

2.1 An Overview of Rapid Prototyping

Rapid prototyping (RP) is a computer program that constructs three-dimensional models of work derived from a Computer Aided Design (CAD) drawing. With the use of rapid prototyping technologies, one can quickly and easily turn product designs into physical samples.

Using a CAD drawing to create a physical prototype is quite simple for the user. First, the machine reads the data from the provided CAD drawing. Next, the machine lays a combination of liquid or powdered material in successive layers. The materials used in rapid prototyping are usually plastics, ceramics, wood-like paper, or metals such as stainless steel and titanium.

With rapid prototyping, each layer is built to match the virtual cross section taken from the CAD model. Therefore, the final model is built up gradually with the help of these cross sections. Finally, the cross sections are either glued together or fused with a laser. The fusing of the model automatically creates its final shape. Rapid prototyping processes can be classified into three major groups which is subtractive, additive, and virtual. As the names imply, subtractive processes involve material removal from a workpiece larger than the final part. For additive process, the process is built up a part by adding material incrementally and virtual processes use advanced computer-based visualization technologies.

Almost all materials can be manufactured using the rapid prototyping operation, but polymers are the workpiece material most commonly being used. Table 2.1 showed the characteristics of rapid prototyping technologies.

Table 2.1: Characteristics of Rapid Prototyping Technologies [2].

Supply phase	**Process**	**Layer creation technique**	**Phase change type**	**Material**
Liquid	Stereolithography	Liquid layer curing	Photopolymerization	Photopolymers (acrylates,epoxi, colorable resins, filled resins)
	Solid-based curing	Liquid layer curing and milling	Photopolymerization	Photopolymer
	Fused-deposition modeling	Extrusion of melted polymer	Solidification by cooling	Polymers (ABS, polyacrylate, etc), wax, metals and ceramics with binder
	Ballastic-partical manufacturing	Droplet deposition	Solidification by cooling	Polymers, wax
Powder	Three-dimensional printing	Layer of powder and binder droplet deposition	No phase change	Ceramic, polymer and metal powders with binder
	Selective laser sintering	Layer of powder	Laser driven sintering melting and solidification	Polymers, metals with binder, metals, ceramics and sand with binder.
Solid	Laminated-object manufacturing	Deposition of sheet material	No phase change	Paper, polymer

2.1.1 Subtractive Processes

Making a prototype has traditionally involved manufacturing processes using a variety of tooling and machines. Usually it takes times which can be from weeks to month, depend on the part complexity. Until recently, this approach has required highly-skilled operator, using conventional metal cutting and finishing machinery to execute operation, one by one until the prototype was finished. Today, subtractive processes used computer-based technologies to speed the process. Essential to this approach are the following technologies [3]:

1. Computer-based drafting packages
   - Can produce three-dimensional representations of part.
2. Interpretation software
   - Can translate the CAD file into format usable manufacturing software.
3. Manufacturing software
   - Capable of planning the machining operation required to produce the desired shape.
4. Computer-numerical-control machinery
   - The capability required to manufacture the part.

When a prototype is needed only for shape verification, a software material is used as the work piece, in order to reduce machining problem. The material intended for the actual application can be the one machined instead, but this approach may be more time-consuming. Subtractive system can take many form, they are similar in approach to manufacturing cell.

2.1.2 Additive Processes

Additive rapid-prototyping operations all build parts in layer. All of the processes describe in this section build part layer by layer. The main difference between the various processes lies in the approach taken to produce the individual slice [4].

Rapid prototyping, in this method, requires an input in the setup from the computer files and in the initiation of the production processes. Following this stage, the machines generally operates unattended and provides a rough part after a few hours. In order to complete the RP process, the part is then put through a series of finishing manual operation (such as sanding and painting). It should be recognized that the setup and finishing operations are very labor-intensive and that the production time is only a part of the time required to obtain a prototype. Generally, additive processes are much faster than subtractive processes; they can take as little as from a few minute to few hours to produce a part.

2.1.3 Virtual Prototyping

Virtual prototyping, a totally software form of prototyping, uses advanced graphics and virtual-reality environments to allow designers to examine a part. This technology is used by a CAD packages to render a part, so that the designer can observe and evaluate the part as it is drawn.

The simplest forms of such systems use complex software and three-dimensional graphics routines to allow viewers to change the view of parts on a computer screen. More complicated versions will use virtual-reality headgear and gloves with appropriate sensors, to let the user observe a computer-generated prototype of the desired part in a completely virtual environment [5].