UNIVERSITI TEKNIKAL MALAYSIA MELAKA

RAPID PROTOTYPING ON BIOMANUFACTURING

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

By:

MOHD FIRDAUS BIN RAMLI 4BMFR B050610123

FACULTY OF MANUFACTURING ENGINEERING

2010

RAPID PROTOTYPING ON BIOMANUFACTURING

MOHD FIRDAUS BIN RAMLI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPENDIX E

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Rapid Prototyping on Biomanufacturing**

SESI PENGAJIAN: 2009/10 Semester 2

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Disahkan oleh:

Alamat Tetap:

Lot 1664 Kg Sg.Sekawang
71250 Pasir Panjang
Port Dickson
Negeri Sembilan

Cop Rasmi:

ABD HALIM HAKIM BIN ABD AZIZ
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

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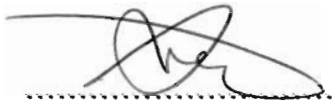
Signature : 

Author's name : MOHD FIRDAUS BIN RAMLI

Date : 25/5/2010

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) with Honours. The member of the supervisory committee is as follow:

Signature : .....

Supervisor : EN.ABD HALIM HAKIM BIN ABD AZIZ

Date : 20/5/10

ABD HALIM HAKIM BIN ABD AZIZ
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

ABSTRACT

This project are highlighted to the study of the feasibility of using new material for producing a product that could replace real bone and to study the capability of RP machine to produce model by using new material other than its usual powder. There are so many RP machines but during this project only 3D printer that will be use that is Zprinter 310. The new material that will be use was called as hydroxyapatite specifically by using cockle shell. This research was begins with process of crushing the cockles using crusher machine and variable rotor mil and the other subsidiaries process. After that the process continues with the selection of suitable binder for the hydroxyapatite. Next step is run the RP process as usual. If the model failed to be created, an analysis was conduct and finds the solution. The RP process is repeated until the model is successfully produces. Finally do the simple analysis such as compression test and visual observation analysis on shape and dimension for the model created.

ABSTRAK

Project ini adalah menjurus kepada kajian keaatas kebolehlaksaan sejenis bahan baru untuk menggantikan tulang yang sebenar dan juga untuk mengkaji kebolehupayaan mesin "*rapid prototyping*" dalam menghasilkan model dengan menggunakan bahan selain dari kebiasaannya.Terdapat pelbagai jenis mesin "*rapid prototyping*" tetapi sepanjang projek ini hanya *3D printer* yang akan digunakaan iaiatu dari model *Zprinter310*. Bahan baru yang akan digunakan adalah dipanggil sebagai *"hydroxyapatite*" atau lebih spesifik adalah dengan menggunakan kulit kerang. Kajian ini bermula dengan menghancurkan kulit kerang dengan menggunakan "*crusher machine*" dan juga "*variable rotor mill*" seterusnya diikuti dengan beberapa process lain.Selepas itu proses seterusnya ialah pemilihan "*binder*" yang sesuai untuk *hydroxyapatite* dan proses RP dijalankan seperti biasa. Jika model gagal dihasilkan, analisis akan di jalankan untuk mengenal pasti masalah dan setelah masalah di selesaikan proses itu akan di ulang semula sehingga model dihasilkan dengan jayanya.Akhir sekali analisis ringkas seperti "*compression test* " dan juga pemerhatian pada bentuk dan ukuran model yang telah dihasilkan.

ACKNOWLEDGEMENT

Alhamdulillah, big thank to Allah s.w.t for his blessings and grant me strength throughout the way in completing writing the PSM report on time.

First of all, I would like to express my greatest appreciation to En.Abd Halim Hakim bin Abd Aziz as my supervisor. Thanks a lot to his helping and give me an easy way in order to complete this report. He is very dedicative and supportive person.

It would be my honor to express special thanks to our Rapid Prototyping laboratory technician Mr.Fairuz because give me lot of information and guide me in order to understanding the 3D printer characteristic, give me motivation, idea and ready to help me to operate a machine anytime.

I also wish to express my appreciation and gratitude to head of material department who is Dr Jariah. She gave me information about hydroxyapatite and name of suppliers in Malaysia. Furthermore, I wish to express my heartiest gratitude to all for the invaluable guidance, suggestions and most of all their assistance which enabled me to complete my report writing. I'll utilize and apply all the knowledge and experience that I gain wisely, in my future days.

Last, but not least, I am deeply indebted and grateful to my beloved parents, family and friends as well who have given me much moral support, encouragement and ideas throughout this research.

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LIST OF ABBREVIATIONS

RP	-	Rapid Prototyping
HA	-	Hydroxyapatite
SLS	-	Selective Laser Sintering
FDM	-	Fused Deposition Modeling
EBM	-	Electron Beam Melting
LOM	-	Laminated Object Manufacturing
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CAE	-	Computer Aided Engineering
CNC	-	Computer Numerical Control
3DP	-	3D printer

CHAPTER 1

INTRODUCTION

1.1 Background

Artificial bone refers to bone-like material created in a laboratory that can be used in bone grafts, to replace human bone that was lost due to severe fractures, disease and another causes.

Bones are rigid organs that form part of the endoskeleton of vertebrates. They function to move, support, and protect the various organs of the body, produce red and white blood cells and store minerals. Bone tissue is a type of dense connective tissue. Because bones come in a variety of shapes and have a complex internal and external structure they are lightweight, yet strong and hard, in addition to fulfilling their many other functions. One of the types of tissue that makes up bone is the mineralized osseous tissue, also called bone tissue that gives it rigidity and a honeycomb-like three-dimensional internal structure. Other types of tissue found in bones include marrow, endosteum and periosteum, nerves, blood vessels and cartilage. There are all 206 bones in the adult human body and 270 in an infant.

Bone grafting is a surgical procedure that replaces missing bone with material from the patient's own body, an artificial, synthetic, or natural substitute. Bone

grafting is used to repair bone fractures or damages that are extremely complex, pose a significant health risk to the patient, or fail to heal properly. Damaged bone can be replaced with bone from other parts of the body (autografts), from cadavers (allograft), or with various ceramics or metallic alloys. However the use of autografts limits how much bone is available, while the other options can result in rejection by the human body.

There has been much research towards creating artificial bone. Richard J. Lagow, at the University of Texas at Austin, developed a way of creating a strong bone-like porous structure from bone powder, which, when introduced in the body, can allow the growth of blood vessels, and which can be gradually replaced by natural bone. Research at the Lawrence Berkeley National Laboratory has resulted in a metal-ceramic composite that has, like bone, a fine microstructure, and which may help create artificial bone.

1.2 Problem statement

Traditionally, the main source of bone for replacement purposes was a cadaver that is dead bodies. Recently, physicians have developed new method for bone replacement by using metals .So that, there are two types of alloys that are titanium and cobalt chromium has been frequently tested but are subject to body rejection. Scientists are looking for hydroxyapatite that is a mineral that makes up about 65 percent of living bone. Attempts to bake natural hydroxyapatite powder into a hard bone substitute have often failed. The high processing temperature needed for baking causes the hydrogen-oxygen mixture to boil off, leaving researchers with a weak ceramic. Strengthening the ceramic with silica and other elements usually causes a high body rejection rate. However we can found hydroxyapatite in other living things such as oyster shell, cockles and many more. Nowadays, scientists are successfully creating

hydroxyapatite chemically in laboratoty. By using the combination of biology and manufacturing technology, this thesis is to study and test the capability of Rapid Prototyping machine to produce artificial bone by using hydroxyapatite.

1.3 Objective of the project

a) To study the feasibility of using cockle powder to replace hydroxyapatite for producing a product that could replace real bone.
b) To study the capability of RP machine to produce model by using material other than its usual powder that is hydroxyapatite using Z-binder.

1.4 Scope

The research is to identify new material that suitable for the bone replacement. Then the research covers and the designation of part using CAD software and to study the capability of rapid prototyping machine to produce the prototype of human bone by using new material that is hydroxyapatite. 3D printer machine is chosen for this project and the hydroxyapatite will be used as the main substance.

1.5 Project outlines

Based on the thesis for Projek Sarjana Muda (PSM) I, an organization has been constructed for the process flow of completion in order to fulfill course of Degree in Universiti Teknikal Malaysia Melaka (UTeM). Below shows the format of the organization:

I. Chapter 1 represents the introduction of the project conducted which is background, problem statement, objectives, scope and project outlines. In this chapter, it explains clearly how the subtopics influence each other in this project.

II. Chapter 2 represents the literature review on the background and basic information about the rapid prototyping, artificial bone, hydroxyapatite and also rapid prototyping machine especially 3Dprinter.

III. Chapter 3 represents the methodology used for conduct this project. This chapter included the planning of the research, flowchart, machine setup process, experimental procedure and the sources of data.

IV. Chapter 4 shows the result and the discussion of experiment and presentation of data that have been collected in the production processes. The progression, experimental data and the analysis have stated in this step.

V. Chapter 5 presents the conclusion of the whole study and recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Prototype is an important part of the research and development process for engineer. Prototype development is a stage in the product development process. Basically a new product is originated as and idea. However the idea is a descriptive statement that can be written or only verbalized. So that, the effective way is by converting the idea into a product concept that includes consumer benefits and features of the product. The concept is developed into working model or preliminary version of the product also known as prototype. Further developments will take place until it is decided as a final product.

During the development process, they allow pre-production testing and serve to emphasize potential problem within the design. Prototypes serve five purposes in the product development process:

a) Experimentation and learning in the product development process

b) Testing and proofing product concepts

c) Communicating concepts to the product development team members, management and customers

d) Synthesis and integration of all components of a product

e) Scheduling the product development process by acting as markers for the end or start of a particular development phase.

In the past, producing a prototype has been a very costly process due to relying on conventional machining process for producing large number of single product. Prototyping or model making in the traditional sense has a long history. There are three phases in the development of prototyping (Chua et al, 2003):

1. Manual prototyping: techniques tend to be craft-based and labor-intensive
2. Soft or virtual prototyping: began in early 1980s with the advent of Computer Aided Design (CAD), Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM)
3. Rapid prototyping of physical parts: also known as solid free-form fabrication, desktop manufacturing or layer manufacturing. It is the process of creating physical models from CAD.

Nowadays the speed of producing a prototype was greatly improved by the introduction of computer numerical control (CNC) machining that increased the speed at which a prototype is developed. With Rapid Prototyping, this time period has even decreased from few days to a few hours.

2.2 Rapid prototyping

Rapid Prototyping is an additive manufacturing process that generates a model of an object directly from a CAD model by building it in layers. For this computerized equipment are used that builds a three-dimensional model of a casting from a CAD drawing. According to Kalpakjian,S.(2006),rapid prototyping is a technology for quickly fabricating physical models, functional prototype and small batches of parts directly from computer aided design (CAD) data.

There are different forms of Rapid Prototyping available depending upon the needs. One can differentiate between them by the methods these systems employ to make the layers. The following list is in order of increasing functionality, sophistication and reusability:

1. Show and tell prototype: serves as a demo for management and businessmen. It also can be used for budget approval or finding a sponsor
2. Mock-up prototype: used to understand the analysis requirements
3. Proof-of-concept prototype: used to explore risks and decide whether to proceed
4. Demo prototype: communicates vision and partial functionality to business people and potential customers
5. Operational prototype: the most functional kind of prototype and may evolve into the final product

The material accretion technologies may be defined by the state of the prototype material before part formation. For the liquid based technologies may entail the solidification of resin on contact with a laser, the solidification of an electrosetting fluid or the melting and subsequent solidification of the prototype material while the processes using the powder compound them either with laser or by selective application of binding agents. Those processes which use solid sheets may be classified according the whether the sheets are bonded with a laser or with an adhesive. The classification of Rapid Prototyping technology is presented as arrangement below.