FABRICATION OF COMPLETED DENTURE VIA 3D PRINTING TECHNOLOGY WITH REVERSE ENGINEERING METHOD

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2017

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

by

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9302010-08-5841

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2017

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TAJUK: **Fabrication of Complete Denture via 3D Printing Technology with Reverse Engineering Method**

SESI PENGAJIAN: **2016/17 Semester 2**

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ABSTRAK

Kajian ini membentangkan proses fabrikasi gigi palsu dengan melaksanakan teknik yang digunakan dalam pembuatan pantas (RM) yang merupakan teknologi percetakan 3D yang melibatkan kaedah kejuruteraan terbalik. kejuruteraan undur (RE) yang telah digunakan adalah kaedah pengimbasan 3D yang sesuai untuk mendapatkan semula data permukaan produk. A peranti pengimbasan Rexcan CS2 + telah digunakan untuk mendapatkan data permukaan model gigi palsu yang lengkap yang diterima dari klinik pergigian. Permukaan diimbas telah ditapis menggunakan Geomagic Studio dan kemudian ditukar kepada format STL sebanyak CAD dan permohonan percetakan 3D. Reka bentuk gigi palsu lengkap telah ditukar kepada format STL untuk pengeluaran corak induk menggunakan mesin Projet HD 3500, salah satu teknik prototaip pantas (RP). Resin akrilik sejuk (VERTEX, Castavaria) akan digunakan sebagai bahan gigi palsu pada gusi.Di bahagian gigi pula akan ditampal dengan resin komposit untuk menambahkan nilai estetika.Kemudian, gigi palsu akhir telah digilap dan diuji pada model edentulous untuk menguji gigitan dan penyesuaian. Gigi palsu yang telah siap akan diuji untuk memastikan kesesuaian dan keselesaan. Hasil akhir gigi palsu juga perlu diperiksa sama ada mempunyai ketepatan yang memuaskan dan baik. Tidak seperti kaedah tradisional fabrikasi, kajian ini mempunyai potensi untuk mengurangkan tempoh masa pembuatan gigi palsu dan membuat ia lebih mudah untuk menggantikan satu set gigi palsu yang telah rosak.

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ABSTRACT

This study presents the denture fabrication process by implementing the techniques used in the addictive manufacturing which is 3D printing technology involving reverse engineering method. Reverse engineering techniques that been applied is 3D scanning method that suitable to recover surface data of a product. A Rexcan CS2+ scanning device was used to obtain the surface data of the complete denture model that received from the dental clinic. The scanned data was refined using the Geomagic Studio and then converted to STL format for CAD and 3D printing application. The complete dentures design were converted to STL format for production of the product using the Projet HD 1000 machine, one of the rapid prototyping (RP) technique. Cold cure acrylic resin (VERTEX, Castavaria) will be used as the denture material on the gum section. On the teeth section, the composite resin will be applied to add an aesthetic value to the part. Then, the final dentures were polished and tested on an edentulous model to test the bite and adaptability. The finished denture will be tested to ensure the adaptability and comfortability. Thus, the result shows a fabricated denture is printed and fixed to the user. She felt comfort while tested the printed complete denture. This method of fabrication by addictive manufacturing is much faster compared to traditional method. The time taken to complete the denture is 5 hours. Otherwise by conventional method consumed about 15 hours. The result for the denture needs to be checked either to be satisfactory and good accuracy. Unlike the traditional method of fabrication, this research has potential to reduce fabrication period of time and make it easier to replace a new set of denture that had been broken.

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DEDICATION

Alhamdulillah first and essential, I would love to commit this project to my almighty God, Allah S.W.T for maintaining me level-headed throughout this process. Allah S.W.T my creator, my strong pillar, my source of inspiration, wisdom, knowledge, and understanding. The Almighty has been the source of my strength throughout this project and on His wings only have I soared.

This mission is also dedicated to my cherished and fantastic dad and mom Mr Syed Idris Bin Syed Hassan and Mrs Nor Azian Binti Alang Ahmad, who encourage me mentally, physically, and spiritually to maintain moving for the duration of the process and encourage me to break the border of real challenge and attain for my precise set of purpose. In additional huge credit for their sacrifices, economic assist thru the thick and thin and to my siblings for the greater push of encouragement. In every darkish cloud, there's continually a silver lining.

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ACKNOWLEDGEMENT

First and foremost, I am very thankful to ALLAH S.W.T for giving me strength and opportunity to complete my Final Year Project 1 report. ALLAH S.W.T that is merciful helped me with His blessed to writing this report.

I would like to take this opportunity to express my sincere gratitude and appreciation acknowledgment to my supervisor Encik Mohd Nazri Bin Ahmad from the Faculty of Engineering Technology, University Teknikal Malaysia Melaka (UTeM) for their essential supervision, patience, constructive comments, motivational support and encouragement towards the completion of this report.

I wish to thank my parents, Mr. Syed Idris Bin Syed Hassan and Mrs. Nor Azian Binti Alang Ahmad and all siblings for their seed of motivation for completing this degree. Not to forget, my beloved friends for their support and willingness in helping me to solve problems and tasks. I would like to acknowledge and pay deep appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for allowing me to conduct my research and providing any assistance requested.

Finally, thanks to the lecturer and assistant engineers in UTeM that assisted me throughout this project. Their persistence and willingness to provide feedback made the completion of this research with an amazing historical experience and thank you to everyone who had participated for the crucial parts in the realization of this project. Thanks also to Mr. Zulkifli bin Jantan the technician of Rapid Prototyping Lab for his kindness for assisting me while working on this project in the lab, and gave a lot of guidance during completing my research.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ACT	-	Abrasive Computer Tomography
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CAM	-	Computerized Aided Manufacturing
CMM	-	Coordinate Measuring Machine
CNC	-	Computer Numerical Control
DDM	-	Digital denture Manufacturing
DOF	-	Degree of Freedom
FDM	-	Fused Deposition Modelling
FPD	-	Fixed Partial Denture
IOD	-	Implant-assisted Overdenture
ISO	-	International organization for Standardization
LOM	-	Laminated Object Manufacturing
OEM	-	Original Equipment Manufacturers
PMMA	-	Poly (methyl methacrylate)
PSM	-	Projek Sarjana Muda
RCD	-	Removable Complete Denture
RE	-	Reverse Engineering
RM	-	Rapid Manufacturing
RP	-	Rapid Prototyping
RPD	-	Removable Partial Denture
RT	-	Rapid Tooling
SGC	-	Solid Ground Curing
SLA	-	Stereolithography
STL	-	StereoLithography
2D	-	Two-Dimensional
3D	-	Three-dimensional
3DP	-	3D Printing

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CHAPTER 1
INTRODUCTION

1.0 Background

3D printing technologies that also synonyms with rapid manufacturing are technologies that emerging as one of the advanced tools nowadays.The 3D printing technologies are processed that realizing the digital design into the physical part.It starts from a digital 3D model, then it will be converted become thin layers by a specific software and tools. Moreover,3D printers also capable of creating an aerospace part, automotive part, complex part shape, firearm part, and many more.It had been implemented in many types of industries due to its functions.Based on the technologies, the 3D printing techniques and tools help to enable rapid fabrication of early product that harvests the visual and functional characteristics of finalizing the end-product.

Reverse engineering is the operation of examining extant products into yield understanding of the product basically in term of the product mechanism and manufacturing.It helps to discover the product technologies principle, system, function through various of analysis study on the product.

Dentures work as replacements for missing teeth that been broken or taken out.The denture can be plugged out and plugged into your mouth when it necessary. Mainly, the denture has two type, which is complete denture and partial denture. A complete denture is a replaces all teeth within an arch of your mouth and gums. Mainly, this project will focus on developing and fabricate a removable complete denture (RCD) by using reverse engineering approach.The RCD will be fabricated with 3D

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printing technology application.The manual method or conventional style will be taking a long period of time to produce.The user having difficulty without teeth in their daily basis due to the long process of fabricating.Furthermore, the manual method involves too many steps, such as making an impression, master model, wax up, mould casting, divesting, preparation and lastly veneering.The reverse engineering method will replicate the existing dentures and the part will be produced by using 3D printing technology.

1.1 Problem Statement

The complete denture that been produced by conventional method enormously relied based on the denture technician or dentist skills in producing it.The process of fabricating denture has many steps and principally associated with labour intensive work.Thus, the quality of the complete denture will depend on the skill of the dentist and usually takes a lot of time to manufacture it.The prosthodontists rated that good quality denture will take up to 10 weeks to be created (The Denture Centre,2017).This project will be focused on to produce complete denture by using 3D printing technology with the help of reverse engineering method.

The reverse engineering approach makes the user easier to replace their broken denture or requires a new set of a denture.This approach will help patients to experience fast dental design and low-cost adjustment.In order to utilize the approach, this project will study the reverse engineering method for complete denture with the help of 3D printing technology.The aims of this project research are to apply the Reverse Engineering technique in setting the denture scanned data (point cloud) by a 3D scanning method, and replicate a set of the denture with 3D printing technology.

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1.2 Objective of Project

The main objective of this study are :

i. To fabricate a set of denture via 3D Printing Technology method.
ii. To implement Reverse Engineering technique in setting the complete denture scanned data by a 3D scanning method.

1.3 Scopes of Project

This research study is to analyze the reverse engineering approach that can be used to replicate a set of the denture.The complete denture will be scanned by the 3D scanner to get the result of the data.The scanner that would be in cloud file format then will be edit with the help of Geomagic software.The Geomagic software will assist to get better result of scan data.Then, after the scan data had been finalized, the research will continue covers in 3D printing technology as rapid manufacturing approach.The material that will be used for the modeling is VisiJet FTI.

1.4 Organization of Project

This report is carried in few chapters and every of it's been declared respectively:

(a) Chapter 1: Introduction

This chapter will define introduction to the project. It contains an introduction, background of the project, problem statement, objectives, and scope of the project.

(b) Chapter 2: Literature Reviews

This chapter review about the studies and research according to the project.

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(c) Chapter 3: Methodology

This section will show how the process flow and the project methodology that has been used in this project.

(d) Chapter 4: Result & Discussion

This part will state out the result that has been obtained and describe the discussion of the project respectively.

(e) Chapter 5: Conclusion & Recommendation

This chapter will discuss the summarization of the project and the major conclusion of the project. Hence the recommendation for a future use.

1.5 Project Planning

This research had been divided into 2 phase to ensure this research proceed well and smoothly. All the phases had been planned well in order to make sure the project will be completed beyond the due date. Phase 1 is the Projek Sarjana Muda 1 (PSM 1) phase which mainly focused on to find out the methodology of this research, the findings of this research.In phase 2, which is PSM 2, it will more focus on the outcomes of this research and result. It also mainly will be discussed in this project conclusion and recommendation.The project planning table can be referred to Appendix 1 Gant chart.

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CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter shows a literature review of fabrication of complete denture by using 3D printing technology with reverse engineering method. The literature review can be defined as a survey and assessment of current literature information based on your topic studies. All the information of the literature will be summarized by showing theories and point of views.

This chapter 2 mainly discussed the literature review that had been done to complete the study of fabrication of complete denture by using 3D printing technology with help of reverse engineering method. It is also will explore the reverse engineering study, the technique of complete denture fabrication, 3D printing technology and dentures.The references mostly have been cited from the book, journal, thesis, article, and website.

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2.1 Type of Denture

Mainly it has several types of denture available nowadays based on the patient conditions.According to Singla (2007), denture has been classified into many types such as a removable denture or known as a full denture, where it is helpful for a someone missing all teeth. There is another type of denture that is classified as fixed partial dentures. Pahlevan (2005) described that the fixed partial dentures are worn by a person that had lost some number of teeth however still having a number of natural teeth. Another classified denture type is an implant over-denture. It is a denture that artificially-made restoration for the tooth roots that have been lost.It used exactness dental attachment that been placed on tooth roots that been saved or into dental implants which the surgically placed the cylindrically form of pore titanium (Vecchiatni *et al.,* 2009). Figure 2.1 shows the three type of classified dentures.

Sources: Dentaire, C. (n.d.). Types of Dentures: Complete, Partial and Semi-Precision Dental Implants. Retrieved May 04, 2017, from http://cliniqueprothesedentaire.com/types-of-dentures-partial-complete/

Figure 2.1: Type of denture.

2.1.1 Partial Denture

Partial dentures are made to fill the distance created with the aid of just a few lacking teeth. Clasps are used to preserve a partial denture in position. they relaxed the denture by clipping on to nearby natural tooth. The partial dentures can be classified into two type which is fixed partial dentures and

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removable partial dentures. Fixed partial dentures (FPDs) are "dental prostheses that are luted, screwed, or mechanically attached or otherwise securely retained to natural teeth, tooth roots, and/or dental implant abutments" (Small, 2011). Removable partial dentures (RPDs) (conventional and implant-supported) treatment is considered a viable option to replace missing teeth as inexpensively as possible, but it has limitations (Etman and Bikey, 2012).

2.1.2 Removable Complete Denture

Complete dentures are full-coverage oral prosthetic devices that replace a whole arch of missing teeth (Abdullaibrahim, 2016). The complete denture purpose is to restore normal contour, functions, comfort, and speech (Memon, 2013). In term of aesthetics reason, the complete denture helps to provide crucial support for your face, it will maintain your face normal contour, especially in mouth section. It additionally helps the user to maintain the function of the teeth on the daily basis such as feeding, talking and smiling.A complete denture appliance got to have a sensible balance of occlusion in order to enhance the stability of the denture functionality or called mastication (Noraniah, 2012). Complete dentures have an effect on speech sounds by altering the dimensions and morphology of the mouth. The insertion of complete dentures plates often leads to speech alteration before using the denture (Khalid, 2015).

2.1.3 Implant Supported Denture

An implant-supported denture is a kind of denture that is supported via and attached to implants. It has unique attachments that in shape over the implants, like a snap fastener or a press-stud. Implants dentures are post surgically placed in the upper lower jaw. According to Johnson (2013), the

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