UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ADDITIVE MANUFACTURING FOR ERGONOMIC IMPROVEMENT OF KNEE SUPPORT DEVICE

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

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2013

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Additive Manufacturing for Ergonomic Improvement of Knee Support Device**

SESI PENGAJIAN: **2012/13 Semester 2**

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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 member of the supervisor is follow:

……..

ABSTRAK

Tajuk bagi projek ini ialah Pembuatan Tambahan Untuk Pembaikan Ergonomik Pada Alat Sokongan Lutut. Tujuan projek ini dilakukan adalah untuk mereka bentuk semula alat sokongan lutut dengan menggunakan kaedah Kejuruteraan Songsang dan proses Pembuatan Tambahan. Matlamat projek ini adalah untuk menghasilkan satu alat sokongan lutut dengan meningkatkan tahap ergonomik dan memberi selesa kepada pesakit. Projek ini memberi tumpuan kepada rekabentuk prototaip alat sokongan lutut berdasarkan geometri lutut pesakit dan jenis kecederaan yang dialami. Kebanyakannya, alat-alat sokongan yang sedia ada untuk lutut terutama bagi pesakit yang mengalami kecederaan teruk seperti patah tulang atau retak mempunyai saiz yang tetap mengikut kepada umur mereka. Peranti ini boleh dilaraskan berdasarkan saiz kaki dan keselesaan kepada pengguna. Walau bagaimanapun, pengguna akan berasa tidak selesa jika alat sokongan ini dipakai untuk jangka masa yang lama. Ini adalah disebabkan oleh permukaan peranti tidak dapat menutup sepenuhnya antara permukaan peranti dan permukaan kaki. Selain itu, kos yang diperlukan untuk menghasilkan sokongan lutut yang sedia ada ini adalah lebih mahal kerana ia memerlukan lebih daripada satu proses mesin dan bahan-bahan yang digunakan untuk membangunkan peranti. Dalam projek ini, beberapa kaedah telah digunakan dalam proses pembangunan alat sokongan lutut. Sebagai permulaan, satu kajian awal telah dijalankan untuk mendapat maklum balas daripada pengguna mengenai alat sokongan lutut yang sedia ada dan keperluan mereka untuk rekabentuk peranti yang baru. Kebanyakannya, responden telah memilih untuk konsep mesra pengguna daripada saiz sedia untuk alat sokongan lutut. Perisian 3D CAD seperti Geomagic Studio 10 dan SolidWork 2010 telah digunakan untuk membangunkan rekabentuk baru untuk menyokong peranti lutut berdasarkan data yang diberikan dari proses imbasan dengan menggunakan peranti pengimbas optik. Analisis Unsur Terhingga (FEA) bagi analisis tekanan telah dilakukan untuk menilai tahap kekuatan

rekabentuk baru bagi alat sokongan lutut dan untuk mengenal pasti bahagian kritikal pada rekabentuk tersebut. Prototaip bagi alat sokongan lutut telah dihasilkan dengan menggunakan mesin Model Pengendapan Terlakur (FDM) dan mesin pencetak 3D. Terdapat dua bahan yang telah digunakan untuk membangunkan prototaip untuk peranti dimana plastik ABS telah digunakan sebagai bahan mesin FDM dan serbuk mengikat telah digunakan sebagai bahan mesin 3D pencetak. Ujian kekasaran permukaan telah dilakukan untuk kedua-dua bahan untuk mengenal pasti tahap kelicinan pada permukaan. Berdasarkan keputusan yang diperolehi, reka bentuk baru untuk alat sokongan lutut adalah selamat untuk digunakan kerana berdasarkan bacaan parameter yang dinyatakan menunjukkan nilai FOS terendah yang terdapat pada rekabentuk kedua-duanya adalah lebih daripada nilai satu. Sebaliknya, jika nilai FOS adalah kurang daripada satu menunjukkan bahawa rekabentuk adalah tidak selamat dan memerlukan pembaikan. Seterusnya, hasil daripada ujian kekasaran menunjukkan bahawa produk yang dihasilkan daripada mesin pencetak 3D mempunyai permukaan yang licin berbanding dengan produk yang dihasilkan daripada mesin FDM. Sebagai kesimpulan daripada projek ini, teknik kejuruteraan terbalik dan proses pembuatan tambahan dapat difahami dan digunakan semasa proses pembangunan bagi alat sokongan lutut. Prototaip bagi alat sokongan lutut telah berjaya dibina dengan menggunakan mesin RP dan kedua-dua bahan yang digunakan untuk membina produk telah diuji untuk menilai prestasi mereka. Walau bagaimanapun, proses yang sebenar telah dipilih bagi projek ini adalah dengan menggunakan mesin Pensinteran Laser Terpilih (SLS) tetapi mesin tidak terdapat di makmal-makmal UTeM.

ABSTRACT

The title for this project is about Additive Manufacturing for Ergonomic Improvement of Knee Support Device. The purpose of this project is to design a knee support device with using Reverse Engineering (RE) methods and Additive Manufacturing (AM) process. Aims of this project is to produce a knee support device with improve ergonomics and comfortably to a patient. This project focused to design a prototype of knee support device based on the geometry of patient knee and type of injury sustained. Mostly, the existing support devices for knee especially for patients that suffers from severe injuries such as bone fractures or cracks have standard size according to their age. The device can be adjusted based on the size of feet and comfort to user. However, users will feel uncomfortable if it is worn for a long time. This is due to the surface of the device does not close completely between the device surface and the foot surface. Besides that, the cost required to produce an existing knee support is quite expensive because they are require more than one process machines and materials use to develop a device. In this project, there several method had been used to done the process development of knee support device. As starting, a preliminary survey was been conducted to gained the feedback from the consumer about the existing knee support device and their requirement for new device. Mostly, the respondents were been choose for user fit concept than the standard size for knee support device. 3D CAD software such as Geomagic Studio 10 and SolidWork 2010 had been used to develop a new design for knee support device based on the data given from the scanning process by using the optical scanner device. The Finite Element Analysis (FEA) for stress analysis was be done to evaluate the strength for the new design of knee support device and to identified the critical section on the design. The prototype for knee support device was be produced using the Fused Deposition Modeling (FDM) machine and 3D printer machine. There are two material were been used to develop the prototype for device which ABS plastic for FDM machine material

and bind powder for 3D printer machine material. The surface roughness test had been done for both material to identify their smooth level. As a result, the new design for knee support device is safe to use because the specified parameter as shown the lowest FOS found in the both design are more than one. Otherwise, if the FOS value is less than one show that the design is unsafe and need some improvement. Then, for the surface roughness test the result shows that the 3D printer product has smoother surface compare to the FDM product. As the conclusion from this project, the RE technique and AM process were understood and was applied during the development process for knee support device. The prototype for knee support device was successfully done by using the FDM machines and the both product materials had been tested to evaluate their performance. However, the actual process was selected for this project is using the Selective Laser Sintering (SLS) but this machine is not available in UTeM's lab.

DEDICATION

To my beloved parents, my supervisor and friends.
All the guidance, wisdom and strength you guys, give me a passion to be the best and help in giving inspiration to complete this project.

ACKNOWLEDGEMENT

Assalamu'alaikum w.b.t.

Firstly, thanks to God. With permission given, I was get to complete my final year project with successfully. My project title for this subject is "Additive Manufacturing for Ergonomic Improvement of Knee Support Device". Thanks a lot to Dr. Shajahan Bin Maidin as my supervisor which has been giving coaching and guide to me during completing this project. Besides that, thanks a lot to my parents, friends and parties which join in helping me direct or indirect to finish this research with successful. Lastly, once again to say thank to all parties had given cooperation to me.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ABS	-	Acrylonitrile Butadiene Styrene
AM	-	Additive Manufacturing
BASS	-	Break Away Support System
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CNC	-	Computer Numerical Control
DSSP	-	Secondary Structure Assignments
FDM	-	Fused Deposition Modeling
FOS	-	Factor of Safety
J	-	Joule
K	-	Kelvin
kg	-	kilograms
m	-	meter
mm	-	millimeter
N	-	Newton
RE	-	Reverse Engineering
RM	-	Ringgit Malaysia
RP	-	Rapid Prototyping
SLA	-	Stereolithography
SLS	-	Selective Laser Sintering
STL	-	Stereolithography
W	-	Watt
3D	-	Three Dimensional
°C	-	Celsius
^	-	Exponential
%	-	Percentage
λ	-	Lamda

μ	-	micro
<	-	Less than

CHAPTER 1
INTRODUCTION

1.1 Project Background

This report presents the Additive Manufacturing (AM) for ergonomics improvement of Knee Support Device. Chapter 2 will describe in detail about Additive Manufacturing (AM) and knee support device. Chapter 3 describes both of these subjected because it will be used during the process of Reverse Engineering (RE). RE was applied to redesign the current product without need to develop a new drawing from any CAD software but the CAD data can be obtained directly from the scanning process. In this project, an optical scanner was used to get the geometry of knee to develop a new knee support device that more comfortable for specific patient. Chapter 4 in this report describe in detail about the process development of knee support device using the RE method and AM process. SolidWork 2010 CAD software was used to complement the design shape of the knee support device couple with Geomagic Studio 10. Finally the finish knee support device was made using the Fused Deposition Modeling (FDM) machine.

1.2 Problem Statement

Mostly, the existing support devices for knee especially for patients that suffers from severe injuries such as bone fractures or cracks have standard size according to their age. The device can be adjusted based on the size of feet and comfort to user. However, users will feel uncomfortable if it is worn for a long time. This is due to the surface of the device does not close completely between the device surface and the foot surface. Besides that, the material such as steel was used to support the position of bones from the larger movement.

In manufacturing process to produce a support device for knee have to undergo several processes such as injection molding, stamping process, stitching, finishing and assembling process. The assembly process of device requires fastener such as screws and nuts to assemble two different of components. Therefore, the cost required to produce a device support is quite expensive. In contrast this project will study on how to improve the manufacturing process in order to reduce knee support device manufacturing cost and time by using AM.

1.3 Objectives

1.3.1 To study about Additive Manufacturing (AM).

1.3.2 To implement Reverse Engineering (RE) technique to redesign the knee support device.

1.3.3 To produce a new design of knee support device that will improve the comfort and ergonomic.

1.3.4 To test and validate the prototype.