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https://doi.org/10.15017/2552946

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 5, pp.87-88, 2019-10-24. 九州大学大学院総合理工学府
バージョン：
権利関係：

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Design and Analysis of 3D Printed Prosthetic Hand for Symbrachydactyly Patients

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Abstract: *A symbrachydactyly is a genetic problem which also synonym as a person with fingerless condition. The patients will have difficulties in daily activities such as to hold an item. To ease the constraints, a customized and patient-specific prosthetic hand is needed with a minimum cost. This project covers the designing process for the prosthetic hand, including computational analysis. Parametric study on the different thickness of the palm cover was conducted to evaluate the performance of the product. Then, the prosthetic hand is fabricated using 3D printing technology. The simulation study suggested that the 5mm thickness of the palm cover was sufficient to the product. The resulting maximum stress variation and total displacement were the indicator in proposing the optimum design.*

Keywords: 3D Printing; Finite Element Analysis; Prosthetic Hand; Symbrachydactyly.

1. INTRODUCTION

Three out of ten thousand newborns are born with symbrachydactyly according to a statistic by Latin-American Collaborative Study of Congenital Malformations [1]. Symbrachydactyly is a genetic problem which caused the finger of the newborn to be underdeveloped or shorten as shown in Figure 1 [2]. There are also cases of fingerless due to accident such as power-tool accident and also finger crushed between door.

Figure 1 Example of Symbrachydactyly Condition [2]

Due to non-life-threatening condition, not much solutions are available for them to improve their life quality or help them with the problems. These problems could hinder them from interacting like a normal person as even a simple task such as holding an item or pushing a button is very hard for them.

Current prosthetic that are available in the market such as the myoelectric or electrical-powered prosthetic hand are not suitable for these conditions due to limited space to place electrical component. It will be too bulky if implemented for people with these conditions [3].

The one solution that was proposed is to design and fabricate a prosthetic hand that do not uses any electrical component. The idea came from a company called E-Nable which uses the wrist to control the prosthetic hand [4]. By using 3D printing technology, a prosthetic hand could be fabricated in a cheaper and faster way compared to other method such as injection molding technique [5]. The 3D printer that will be used for the project is Fused Deposition Modelling (FDM) type which uses plastic filament as it is cheapest type and are easy to handle by anyone with minimal training [6].

The project will cover on the design of prosthetic hand using a Computer Aided Design (CAD) software and analyzed the design on the most critical part for different thickness. Different thickness of design would result in different behavior toward energy absorption [7]. Analysis is done to know the behavior of the design toward real life situation [8]. Finally, the prosthetic hand would then be fabricated using a 3D printer. The project would help to improve the life of those people with fingerless conditions.

2. METHODOLOGY

This project consists of three (3) major steps which are: (a) design process, (b) analysis process and (c) fabrication process.

2.1 Design Process

The first step is to scan the hand of the one with the fingerless patient to model the prosthetic hand from to have better fitment and better comfort for the user. The prosthetic hand would then be designed based on the scanned hand as per shown in Figure 2.

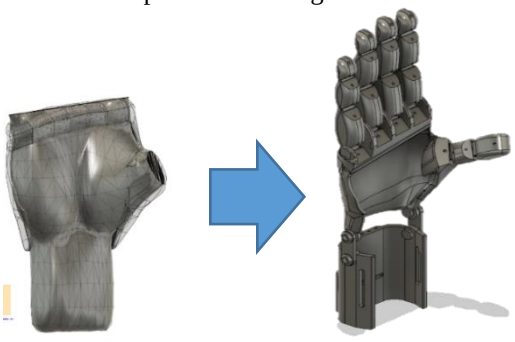

Figure 2 Process of Producing Prosthetic Hand from 3D Scanned File

2.2 Computational Analysis

The computational analysis was conducted using commercial finite element software, Ansys v19. The static analysis was focused on the most critical part which is the cover palm. Five different thickness of cover palm were considered which were 3mm, 4mm, 5mm, 6mm and 7mm. The model was discretized into tetrahedral

elements to predict the behavior of each section. The load of 10kg were assigned to the palm as illustrated in Figure 3. The performance of the model was predicted on the resulting total deformation and stress distribution of the model.

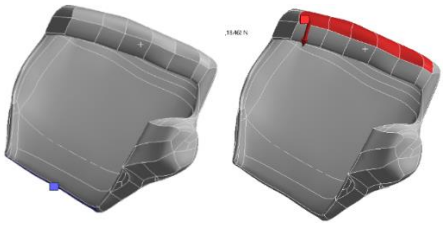

Figure 3 Loading and Boundary Conditions in the analysis. Constraints(Left) and Loading of 10kg (right) Conditions

2.3 Fabrication Process

The design would then be reworked if needed. The prosthetic hand design would then be exported to a slicing software for the 3D printer to read before it could fabricate the prosthetic hand. Once it is done printing, it would then be assembled to make a functional prosthetic hand.

3. RESULTS AND DISCUSSION

The design of the prosthetic hand was successfully developed and analyzed. The result for the analysis is as follow. For stress, it improved significantly when increasing the thickness of palm cover until 5mm. It shows minimal improvement when exceeding 5mm thickness as shown in Figure 4. The maximum stress that the material (Polylactic Acid) used could handle was 37.45MPa [5]. Similar case goes for the results of total deformation as per shown in Figure 5. All thickness would not fail but the best design would be of 5mm thickness with the safety factor of around 7.2. The deformation occur is insignificant as the deformation is too low under 1mm for 5mm thickness.

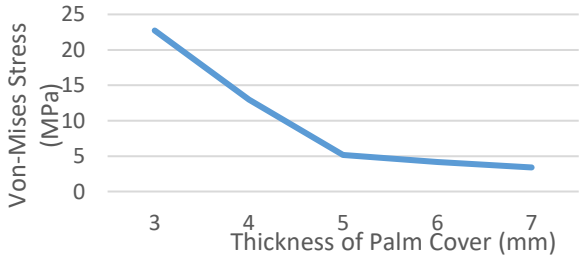

Figure 4 Maximum von Mises Stress in the Palm Cover

Once the best thickness was picked which is 5mm which has the suitable safety factor without increasing too much on the weight of the prosthetic hand, the design is ready for fabrication using 3D printer. The design need to be set-up according to the findings of the analysis. The setting used is of 1.2mm wall thickness with 100% infill. The 3D printer would then fabricate the prosthetic hand part by part. Once completed, it would be assembled into a working model as shown in Figure 6. The working model could be worn by the patient for its intended purpose straight away after assembly.

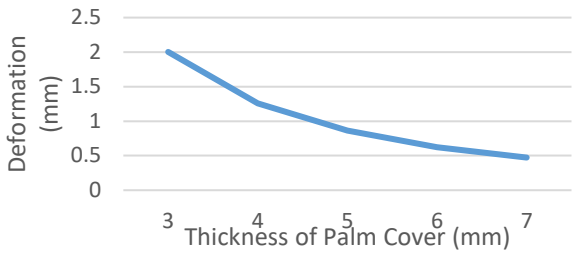

Figure 5 Deformation of Palm Cover

Figure 6 3D Printed Model of the Prosthetic Hand

4. CONCLUSION

The project's objective was successfully achieved which is to design a prosthetic hand, analyze the critical part and lastly to fabricate the prosthetic hand. The best thickness determined for the palm cover is 5mm with the safety factor of 7.2. The prosthetic hand also works as intended.

ACKNOWLEDGMENT

This research was supported by Universiti Teknologi MARA, UiTM under Grant No. 600-IRMI/PERDANA 5/3 BESTARI (103/2018). We also thank and acknowledge to Ministry of Education, Malaysia for the financial support.

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