
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## Design and Finite Element Analysis of Ergonomics Prosthetic Leg

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

by

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design and Finite Element Analysis of Ergonomic Prosthetic Leg**

SESI PENGAJIAN: **2015/16 Semester 2**

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I hereby, declared this report entitled "Design and Finite Element Analysis of Ergonomics Prosthetic Leg" is the results of my own research except as cited in references.

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# ABSTRAK

Kaki palsu biasanya digunakan untuk warga kurang upaya. Terdapat beberapa aspek yang perlu disiasat mengenai kepada ketidakselesaan pengguna daripada kaki palsu. Ketidakselesaan untuk pengguna kaki palsu adalah berbeza pada berlainan jenis kaki palsu. Kebanyakan ketidakselesaan berlaku kerana pada tekanan pada kaki kudungya yang perlu dikaji lagi. Oleh itu, jika masalah pada kaki palsu boleh dikenal pasti ketidakselesaan pada kaki kundungnya boleh dielakkan. Masalah utama kaki palsu adalah kekurangan aspek ergonomik. Projek ini bertujuan untuk menentukan aspek ergonomik dan menganalisis unsur-unsur sehingga di dalam simulasi untuk kaki palsu. Projek ini akan mengkaji pada pergelangan kaki pada kaki palsu. jangkaan lanjut untuk membuat pembaharuan dan bandingkan dengan kaki palsu yang sedia ada dengan melakukan beberapa kaedah tambahan untuk meningkatkan reka bentuk kaki palsu. Terdapat beberapa kaedah yang akan digunakan untuk mereka bentuk kaki palsu seperti unsur terhingga pada sendi kaki palsu untuk mengesan ketidakselesaan pengguna. Keberkesanan kaedah ini akan membantu untuk membuat kaki palsu pergelangan kaki yang selesa dan mengikuti dengan aspek manusia pada terma ergonomik.

## ABSTRACT

The prosthetic leg is commonly used for the disable people. There are several aspects that should be investigated regarding to the discomfort of the user of the prosthetic leg. The discomforts for the prosthetic ankle users are different on different type of prosthetic leg. Most of the discomfort occurs because of the on the stress on the amputee leg which should be further studied. Thus, if the problem on the prosthetic leg can be identified the discomfort of the amputee can be avoided. The main problem of the prosthetic ankle is the lack of ergonomic aspect. This project was aimed to determine the ergonomic aspect and finite element analysis in the simulation for the prosthetic leg. This project will study on the ankle of a prosthetic leg. Further expectation is to innovate and compare with the existing prosthetic leg by performing some additional method to improve the design of the prosthetic leg. There are several methods that will be used to design the prosthetic leg such as finite element on the socket of the prosthetic leg to detect the discomfort of the user. The effectiveness of this method will help to make a prosthetic leg that is comfortable and follow with the human aspect on the ergonomic terms.

# DEDICATION

This dedication firstly to Allah S.W.T for giving strength and good health to perform this duty to complete this project. Great appreciation also to my parents the two persons that is always give support and motivation. The person that guide and always give advice to never give up easily when the time became hard on the implementation of this project. Also dedicated appreciation to my siblings who have always give supported and helped on the hardest time.

Thank you.

# APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

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| | | |
|---|---|---|
| B.C | - | Before Century |
| FEA | - | Finite Element Analysis |
| FEM | - | Finite Element Method |
| 1D | - | 1 Dimensional |
| 2D | - | 2 Dimensional |
| 3D SOLID | - | 3 Dimensional Solid |
| HF & E | - | Human Factor and Ergonomic |
| $WRMD_S$ | - | Work Related Musculoskeletal Disorder issues |
| OSHA | - | Occupational Safety and Health Administration |
| PL | - | Prosthetic Leg |
| SACH | - | Solid Ankle Cushioned Heel |
| ESAR | - | Energy Storage and Return |
| CAD | - | Computer Aided Design |
| CAE | - | Computer Aided Engineering |
| SS Adapter | - | Socket and Shinbone Adapter |
| SA Adapter | - | Shinbone and Ankle Adapter |
| BOM | - | Bill Of Materials |
| N | - | Newton |

# CHAPTER 1

# INTRODUCTION

## 1.0 Background of The Project

Prosthetic is a fake substitute or substitution of a part of the body such as a tooth, eye, a facial bone, the sense of taste, a hip, a knee or another joint, the leg, an arm, and so forth. Prosthesis is intended for practical or restorative reasons or both. Run of the mill prostheses for joints are the hip, knee, elbow, lower leg, and finger joints. Prosthetic inserts can be parts of the joint, for example, a one-sided knee.

Prosthesis might be removable, as on account of most prosthetic legs or a prosthetic bosom structure utilized after mastectomy. A man who utilizes a removable prosthesis, for instance, a simulated hand, might need to have more than one accessible for various sorts of undertakings. Different sorts of prosthetic gadgets are for all time embedded, similar to a counterfeit hip, testicle or tooth.

With advances in the biomedical sciences, a couple of exploratory prostheses have been incorporated with body tissues, including the sensory system. These exceptionally propelled gadgets can react to summons from the focal sensory system, all the more nearly approximating typical development and utility. "Prosthesis" comes through New Latin from the Greek "prostithenai" signifying "to add to, or to put furthermore." [http://www.medicinenet.com/script/main/art.asp?articlekey=15985].

The advancement of prosthetics is a long and storied history, from its primitive beginnings to its modern present, to the energizing dreams without bounds. As in the improvement of whatever other field, a few thoughts and innovations have worked and been developed, for example, the settled position foot, while others have fallen by the wayside or get to be old, for example, the utilization of iron in a prosthesis.

The history of mechanized leg started around 1500 B.C. and has been developing from that point forward. There have been numerous refinements to the primary peg legs and hand snares that have prompted the exceptionally individualized fitting and until today's gadgets and technology. Be that as it may, to acknowledge how far the prosthetics field has come, we should first look to the old Egyptians [John Marshall (2015)].

Every gadget will be different, based upon the level of body removal, physical capacity and requirements. The prosthetic will make a gadget that is specially designed to fit human body. Human body prosthetic will make recommendations in light of the sort of removal and your action level. A prosthetic is fundamentally an augmentation of the body. A standard prosthesis is made of ordinary segment parts that make the leg and prosthetic foot. These parts are associated with an attachment that fits over your remaining appendage.

The attachment permits the prosthetic gadget to associate with the residual limb. An extra layer, called a liner, fits over the leftover appendage and gives a hindrance between the skin and the attachment. The liner gives pad and solace while giving a superior fit to the attachment. It is fundamental that the attachment fits accurately. An ineffectively fitted attachment can prompt agony, wounds and rankles on your remaining appendage. The most well-known attachment alternatives are suction, vacuum and stick lock.

A prosthesis can look anyway the person need it to. From the simply useful look of the mechanical parts to a restorative cover that resembles a characteristic appendage, your alternatives are perpetual. In the event that you need to put forth a design expression, you can have your attachment secured in your most loved group's logo or decorate it with your most loved shading or example. The prosthesis is an augmentation of you and your style

Innovation keeps on changing the prosthetic business sector. With advances in the microchip knee and foot, and propelled hands and attachments, prosthetics keep on offering new chances to enhance the way of life of individuals with appendage misfortune. This can discover more data on the person prosthetic alternatives by going to the Amputee Coalition's National Limb Loss Resource Center.

## 1.1 **Statement of Problems**

The problems regarding prosthetic leg are on the user comfort. Different prosthetic leg has different problem to the user. This research shown the prosthetic leg model has problems on the discomfort on the part that the prosthetic is put on or use. Not much research done on the stresses that occur using the prosthetic leg. The older design shows the lack of ergonomic aspect while people are using it.

There are several discomforts that occur on the prosthetic legs. In spite of the fact that there are various basic issues amputees experience, volume change inside the attachment is maybe the most dangerous in light of the fact that it can prompt different issues, including diminished solace, expanded shear powers, expanded weight on hard prominences, pistoning and skin breakdown, and in addition a poor walk design. Attachment weight on the delicate tissue of the appendage is the fundamental driver of this volume change. One approach to deal with this change is to include socks as the day goes on; another strategy is to have bladders in the attachment that can be pumped up with air or liquid as the appendage loses volume. The issue with any of these techniques, notwithstanding, is that the weight in the attachment will eventually be exacerbated by the expansion of the additional material, which can bring about additional loss of volume in the appendage.

The volume variance problem occur through the span of a day can likewise bring about expanded weight in specific territories on the grounds that the appendage can settle further into the attachment, permitting hard zones to end up more unmistakable and prompting more weight, at last making more agony and potentially tissue breakdown. These attachment fit issues can likewise emerge from different issues in the amputee's life, for example, weight increase or misfortune, or youth development.

There is also 'Pistoning', which is a circumstance in which the appendage moves too much in the attachment, can likewise happen. This can make more noteworthy shear strengths between the appendage and the attachment and higher crest weights amid stacking reaction. Pistoning might be brought on by various distinctive things including poor suspension, an inadequately planned attachment, or volume changes of the appendage.

Other than that the Skin wellbeing is another conspicuous issue, and, if untreated, can prompt difficult issues. Consistent negative weight on the exceptionally distal end of the appendage may bring about blushing of tissues and may prompt rankles, ulcerations, and at last such issues as verrucous hyperplasia. Any of the above issues can add to or cause an unnatural walk example, for example, limping or an awry step. This may put superfluous powers on the sound appendage and additionally whatever is left of the body, and can bring about abuse issues to these ranges [Byron Backus, CP (2005)].

### 1.2 Objective of The Study

The project objectives are to determine the ergonomic aspect and finite element analysis in the simulation for the prosthetic leg.

The main objectives are:

- To innovate a new prosthetic leg.
- To determine the finite element analysis using SolidWorks software.

## 1.3 Scope of Project

The main idea of this project is to determine the ergonomic aspect and finite element analysis in the simulation for the prosthetic leg. Hence this was done in certain scope to help ease the journey of the project. The scopes of this project are:

- This study is the prosthetic leg is selected from the ankle to the ground.
- The size of the prosthetic leg is limit less than 8 inch.
- Anthropometric is based on adult Asian.
- Finite element analysis by using SolidWorks software.

## 1.4 Significant of Project

The method that been propose in to help to innovate a new ankle prosthetic leg that is tested by using the SolidWorks software and follow on the ergonomic aspect of the comfort of disable people. Hence it is to shorten the period of manufacturing the product with less mistake and problem.

## 1.5 Summary

This chapter is basically explains on the importance of prosthetic leg and its importance on the users' comfort. Other than that it is to point out some of the main part which is the objectives, scope where the project target and focus are. It also shows the significant of the project. The time of the project is followed by the Gantt chart (Appendix A) in the frame work given.

# CHAPTER 2

# LITERATURE REVIEW

## 2.0 Introduction

This section will explain related to the prosthetic leg user that makes the user discomfort and some problem on the prosthetic leg. The method that will be used to overcome the situation on the prosthetic leg will be using the finite element process to detect the stress on the part of the prosthetic leg. The prosthetic leg is design based on the anthropometric data that will be collected to design this prosthetic leg. This will help to create a new and comfort design of prosthetic leg for the user.

## 2.1 Finite Element Analysis

The finite element analysis (FEA) is a numerical procedure for finding estimated answers for limit esteem issues for halfway differential conditions. It is likewise alluded to as limited component examination. FEA subdivides a vast issue into littler, less complex, parts, and called limited components. The basic conditions that model these limited components are then amassed into a bigger arrangement of conditions that models the whole issue. FEA then uses variation strategies from the analytics of varieties to surmise an answer by minimizing a related blunder capacity.

Finite Element Analysis (FEA) is utilized to perform the stress –strain investigation demonstrating the basic and different level at different areas in the segment. The conduct of the component is surely understood under the backing and load frameworks. In addition, the scope of arrangement flexibility must be tested to ensure that the capacity of the segment is come to the prerequisite [Pitchaya Rayothee et al, 2014].

FEA is software that purpose to solve issues on the product modelling and virtual environment. In other hand it is also used by engineer to solve many complex structural problems which it is an application for Finite Element Method (FEM). Figure 2.1 that is shown in it is the finite element in the software. Most commonly used the FEA software is in the biomechanical and automotive industries.

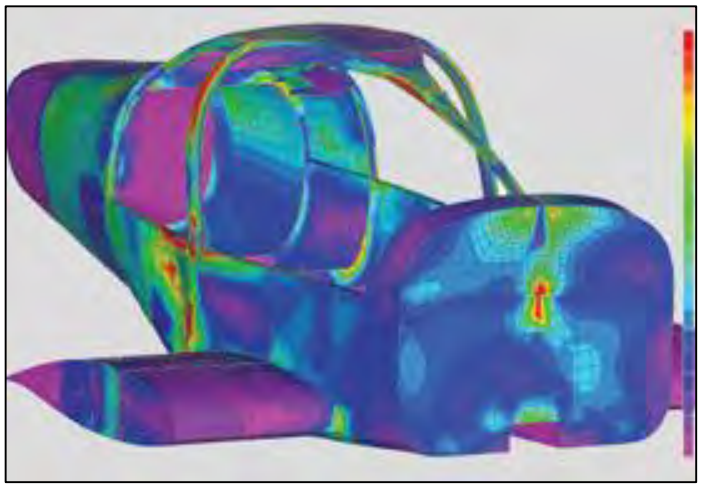

Figure 2.0 Example of Finite Element

(Source: <https://www.plm.automation.siemens.com/en_us/plm/fea.shtml> 10/4/16)

FEA is design software that shape the form in using a model comprises of a system point that is called “nodes”. It is structural properties of a model that connecting all of the nodes as a finite element which to form meshing and contain materials. The thickness of the

limited component lattice may fluctuate all through the material, contingent upon the expected change in anxiety levels of a specific range.

There are many ways to do finite element testing such as by using one dimensional (1D beam), two dimensional (2D shell) or three dimensional (3D solid). By utilizing shafts and shells rather than strong components, an agent model can be made utilizing fewer hubs without trading off precision. There are some modeling scheme that can be defined such as section areas, plate thickness, bending stiffness, and moment of inertia.

In other term there are also several elements that are important to simulate the effect that can be applied to the FE model such as nodal, elemental and acceleration body loads. The nodal is elements that consist of velocity, moments, displacement and others. In elemental also there are pressure, temperature and heat flux as the element in the elemental.

There are many benefit by using the FEA software it can refine the existing product and new product to make sure the design that is develop is appropriate to manufacture base on the FEA. It also can improve the performance of the product, predict and reliability. Hench it optimizes the design and reduces some material usage. It also can evaluate the different design and materials additional reduce the physical prototyping and testing. Other than that FEA also help the engineer to mass production saving on the material [https://www.plm.automation.siemens.com/en_us/plm/fea.shtml].

Prosthetic ankle is widely used for disable people to move around acting like other normal people. This finite element will help the design of the prosthetic ankle more convenient to make it more comfortable for the disable people. Thus in this project it is to focus on the problem of the discomfort of the prosthetic ankle for the disable people. It

will make the disable people have the same feeling with the normal people that will boost their confident level.

## 2.2 Ergonomics

Ergonomic is an important aspect in design a product for human used. The several item that is take for note such as comfort design, functional design and system that is known as human factor and ergonomic (HF&E) which the act of to develop a product that interact with the product and the general population that is using the product. The field has seen commitments from various controls, for example, brain research, building, biomechanics, mechanical outline, physiology, and anthropometry. Generally, it is the investigation of outlining hardware and gadgets that fit the human body and its subjective capacities. The two terms "human variables" and "ergonomics" are basically synonymous.

Ergonomics (or human components) is the experimental control worried with the comprehension of communications among people and different components of a framework, and the calling that applies theory, standards, information and techniques to plan so as to advance human prosperity and general framework execution. HF&E is utilized to satisfy the objectives of word related to the occupational health and safety. It is important in the outline of such things as sheltered furniture and simple to-use interfaces to machines and gear. Ergonomic configuration is important to anticipate dull strain wounds and other musculoskeletal issue, which can create after some time and can prompt long haul handicap. Human elements and ergonomics are taken for notice with the "fit" between the client, hardware and their surroundings. It makes note of the client's capacities and restrictions in trying to guarantee that errands, capacities, data and the earth suit every client.