DEVELOPMENT OF PROSTHETIC LEG USING MAGNETORHEOLOGICAL DAMPER

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Design and Innovation)

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DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledged."

Signature : ……

Name : WAN NURAZRI BIN WAN BUKHARI

Date : ……

This dedication to my beloved parents, siblings and supervisor who encouraged me to finish my thesis during my study at Universiti Teknikal Melaka, Malaysia. I am very thankful to you all.

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ABSTRACT

The amputees are classified as a person that had lost their leg due to the diseases, in an accident or in battlefields. The amputees are actually struggled in the daily life because they cannot walking or running like normal person. The aim of the project is to redesign the prosthetic leg using the Magnetorheological (MR) Damper as actuator. The previous studies had been studied with the help of the similarity of the normal person's gait in the previous researches. House of Quality (HoQ), Morphological chart and Weighted Decision Matrix (WDM) were conducted in term of the engineering design process as the main criteria to determine the new design. The observations of the existing product had been made that needed to redesign and reproduce a better solution for the amputees. The 3-bar mechanism had been used in this project to replace the usual 4-bar mechanism that had been developed in the previous design. The analysis had been made as the result to compare between the new design and existing design. Hopefully, the newer design will be improved the human gait that is used by the amputees and also improve the usage of the prosthetic leg in the future.

ABSTRAK

Orang yang mengalami kehilangan anggota kaki mereka diklasifikasikan sebagai orang yang telah kehilangan kaki kerana sebab-sebab tertentu seperti mempunyai penyakit, kemalangan atau ketika di medan perang. Mereka ingin mempunyai kehidupan seperti orang biasa tetapi disebabkan kehilangan anggota yang menyebabkan tidak boleh menjalankan aktiviti seharian seperti berjalan atau berlari. Tujuan projek ini adalah untuk menambahbaikan reka bentuk kaki palsu menggunakan dengan Magnetorheological (MR) peredam. Penambahbaikan dan reka bentuk yang terbaru telah dilakukan dan juga mengkaji kajian sebelum ini dengan bantuan persamaan gaya berjalan orang yang biasa dalam penyelidikan sebelumnya. Kriteria utama proses reka bentuk telah dijalankan untuk menentukan reka bentuk terbaru seperti Rumah Kualiti (HoQ), Carta Morfologi dan Keputusan Berwajaran Matrik (WDM). Pemerhatian produk yang sedia ada telah dibuat yang diperlukan untuk mereka bentuk semula dan menghasilkan penyelesaian dan produk yang lebih baik untuk pesakit. Mekanisma 3-bar telah disahkan untuk digunakan dalam projek ini untuk menggantikan mekanisma 4-bar yang telah sedia ada dijalankan pada masa sebelum ini. Analisis telah dijalankan untuk membandingkan perbezaan diantara reka bentuk baru dan reka bentuk yang sedia ada. Mudah-mudahan, reka bentuk yang terbaru akan meningkatkan gaya berjalan manusia yang digunakan oleh para pesakit dan juga meningkatkan penggunaan kaki palsu pada masa akan datang.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The new technology in the recent years had improved the lifestyle of the person in the daily life. For example, people nowadays used a various types of devices and gadgets such hand phones and tablets because of the demands throughout the world. Also in the medicine technology, there are many improvements nowadays especially for the handicapped person that also want their own demands to live as like as the normal person. The handicapped person also have a feeling as the normal person but living without one or more parts of the body. Amputations are the removal parts of the body which is enclosed by skin. This is happened when the person involved with accidents either at the work place, on the road or battlefield.

Prosthetic leg is an artificial limb that is attached to where the leg had been amputated. There are many types of leg these days which is consists of three common major components; the pylon, the socket and the foot system. Besides, it is designed to help the amputees to do daily activity like normal person. The Greek,

Egyptian and Romans are among the earliest historical account of using the prosthetic leg. The prosthetic legs are originally made of basic materials which are the woods and metals with the attachment of leather material held to the body.

The design is depends on the types of the prosthetic leg. There are two types of prosthetic leg which is the Above Knee prosthetic leg (AK type), Below Knee prosthetic leg (BK type). The Above Knee prosthetic leg or AK type is leg that had been amputated of the missing the whole majority of the leg. BK type or the Below Knee prosthetic leg is amputated below the knee of the leg. Meanwhile, semi active prosthetic leg is the combination of the active and passive system of the prosthetic leg. The active prosthetic leg is the leg that is used the mechanism that can do a similar gait as the normal person walking. Most of the prosthetic leg are passive which is has no ability to adapt to the change of the environment. Active prosthetic leg can adapt with environment by using sensor which is controlled the actuator based on user response. The usage of the hydraulic actuator that been used to provide a swing gait of the walking manner. For the passive system, there are just a simple type with have not certainly functioned as the normal person gait. In recent years, there are many studies and researches to improve the prosthetic leg design and function to the exact natural gait of the normal person.

1.2 PROBLEM STATEMENT

The existing product of the prosthetic leg which is the Above Knee prosthetic leg (AK type) had been designed by using the Magnetorheological (MR) damper as actuator as shown in Figure 1.1. The design of the prosthetic leg is must require some studies on the MR damper, mechanism design, some improvement and the natural gait of the normal person. The analysis will be undergone for the whole prosthetic leg for performance testing and use a suitable material to overcome the weight from the previous prosthetic leg.

The existing prosthetic leg that had been designed is very heavy and not suitable to use and cannot be tested to the amputees. The existing design needed a newer mechanism to ensure more efficient usage. The prosthetic leg needed to be redesign to improve the optimization and design in the new proper ways to overcome the problem and recreate the natural gait of the normal person in daily life.

Figure 1.1: The existing prosthetic leg with MR Damper

1.2.1 Objective

The objectives for this project are:

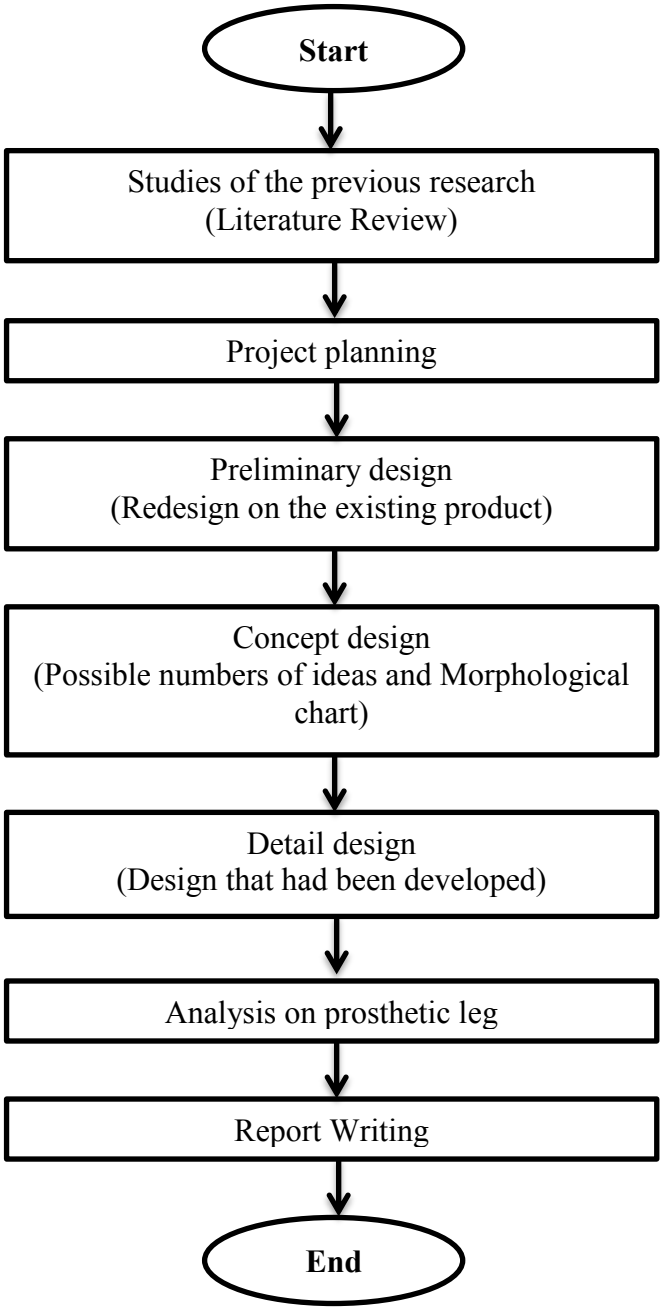
i. To analyse the existing product of prosthetic leg using magnetorheological (MR) damper as actuator.
ii. To redesign the prosthetic leg to control two joints.

1.2.2 Scope

The scopes of this project are:

i. To study the existing MR prosthetic leg mechanism.
ii. To propose the improvement for the existing design.
iii. To design and optimize the MR damper prosthetic leg.
iv. To analyse and simulate the new design.

1.2.3 Flow chart



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the previous studies on the design and analysis of the prosthetic leg had been discussed. The characteristic of the normal person"s gait also been discussed in this chapter. The types of prosthetic leg such as the Above Knee type and Below Knee type is been referred to ensure the understanding of the prosthetic leg as well as the characteristic of MR damper and MR fluid that were discussed to know it clear and the characteristic in the previous studies.

2.2 PROSTHETIC LEG

Prosthetic leg can be classified as an artificial limb or fake leg that is attached to where the leg had been amputated due to disease and trauma such battlefield war and accidents. Nowadays, there are many types of prosthetic leg that had been produced in the market throughout the world to help the amputated person to have a life as usual as like the normal person as shown in Figure 2.1. There are three main components that are commonly found in prosthetic leg such as the socket, pylon and the suspension system or foot system.

Figure 2.1: Various types of prosthetic leg (biomed.brown.edu)

The socket of the prosthetic leg is the components that to ensure the joints between the residual limbs and the prosthetic socket. It is functioned as to optimize the proper fit but it must make by the custom made by the patient itself according to the shapes and the condition of the residual limb. Furthermore, it is ensure not to harm damage to the skin and causing irritation. The pylon is the common major component of the prosthetic leg that is the frame or skeleton that provide a structural support that usually used by using a metal materials. In recent years, there had been many development of upgrading into another material such as carbon fiber composites due to the lightweight properties.

Furthermore, the pylon can be covered by using a foam-like material that can be shaped and colour according to the amputated person skin tone to give more realistic appearance. The suspension system is acts as the attachments to keep the

prosthetic limb to attach to the body. It is depends on the active and passive system or it is called as harness system as the attachments to stay attach firmly to the residual limb.

2.3 HUMAN GAIT ANALYSIS

The gait or a person‟s manner of walking is adapting on the knee damping from the gait of the amputees just by using a local sense of knee force, torque and position of the prosthetic leg. User adaptive knee is successfully controls the early stage of stance of the damping, which is undergo biological realistic of knee flexion. The damping must match with the requirement of the amputee‟s gait in form of walking speed, style and body size (Herr, H., Wilkenfeld, A., 2003).

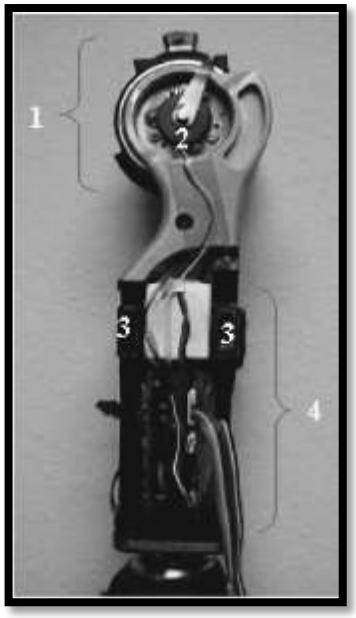


Figure 2.2: Variable-damper knee prosthetic (Herr, H., Wilkenfeld, A.)

Figure 2.2 shows the variable-damper knee prosthetic mechanism from the previous research. The numbering part from the figure is shown that the complete device of

the variable-damper knee prosthetic. The device is functioned with the actuator (1), angle sensor (2), strain gauge sensors (3) and electronic board/battery.

Figure 2.3 shows the pictogram of the walking gait of the human being. There are five basic movement of walking gait such stance flexion, stance extension, pre-swing, swing flexion and swing extension (Herr, H., Wilkenfeld, A., 2003). Firstly, the stance flexion is occurred when the knee stance begins to flex slightly for shock absorb as well as to keep the centre of gravity. Next movement is called stance extension. The situation when the knee stance is reached maximum flexion; the joint begins to extend again. Pre-swing or also called as "knee break" that is performed when the leg of the supporting leg begins to flex again in preparation for leaving the ground. Next, the swing flexion was happened when the hip flexed and the knee reached the angle, the leg leaves the ground and the knee continues to flex. Finally, the swing extension was happened when the knee begins to extend which is maximum flexion angle is at maximum during swing and the knee is in full extension and the next walking cycles begins.

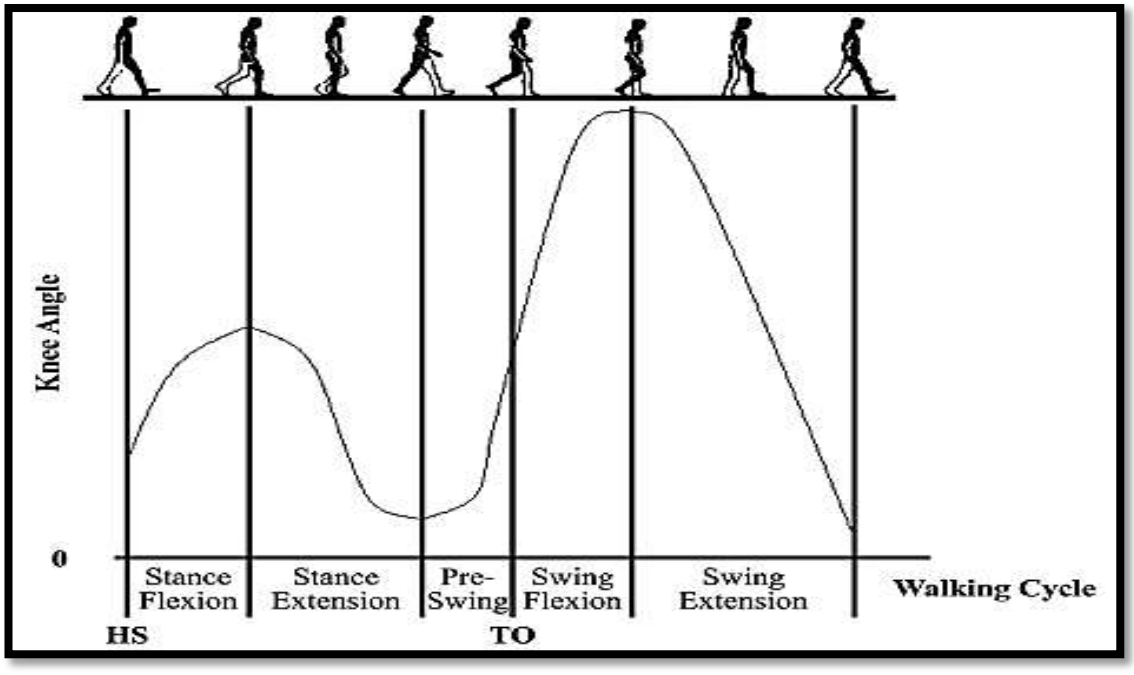


Figure 2.3: Five basic movement of walking gait (Herr, H., Wilkenfeld, A.)

2.4 ABOVE KNEE PROSTHETIC LEG (AK type)

The Above Knee prosthetic leg or AK prosthetic leg type for short name which is used by the amputees that had been amputated the rest of the leg. It is also designed for the missing the majority of the leg. In medicine world, it is called a trans-femoral prosthetic leg. The fundamental common components for the prosthetic leg that is used are such as socket, foot, knee, thigh, hip joint and shank. But, this type of leg is more expensive than Below Knee prosthetic leg (BK type) because it is has more functions. Figure 2.4 shows the basic components of the AK prosthetic leg that is commonly used in the AK leg.

Figure 2.4: The basic components of the AK prosthetic leg (www.amputee-coalition.org)