



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ERGONOMICS AND FLEXIBLE SHOE INSOLE

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

by

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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) (Hons.). The member of the supervisory is as follow:

.....
(Dr. Suriati Binti Akmal)

ABSTRAK

Lapik dalam kasut adalah salah satu komponen utama kasut yang direkabentuk untuk melindungi kaki manusia daripada kesakitan dan penderitaan yang dirasakan ketika memakai kasut. Seseorang yang bekerja dalam kedudukan berdiri mempunyai kemungkinan untuk mendapatkan kecederaan belakang. Cara untuk menyelesaikan masalah ini adalah untuk mendapatkan pembedahan atau untuk membuat lapik dalam kasut khas untuk mengurangkan rasa sakit. Oleh itu, pilihan yang diberikan adalah diluar kemampuan ekonomi. Dalam usaha untuk menangani masalah ini, satu penyelesaian yang dicadangkan adalah untuk merekabentuk dan membangunkan lapik dalam kasut yang mempunyai ciri-ciri ergonomik dan fleksibel di samping mengekalkan nilai estetik pada rekabentuk lapik dalam kasut tersebut. Lapik dalam kasut tersebut akan dibuat oleh bahan yang boleh diguna semula dimana ia mampu untuk mengurangkan kos. Pembangunan reka bentuk baru bermula dengan memahami jenis lapik dalam kasut yang terdapat di pasaran. Di samping itu, antropometri kaki dikaji untuk menentukan dimensi untuk dijadikan rujukan buat rekabentuk lapik dalam kasut yang baru. Taburan tekanan diatas tapak kaki dikaji dengan tujuan untuk menentukan bahagian yang mengalami tekanan yang paling tinggi di kaki. Kemudian, rekabentuk baru dicadangkan dengan menggunakan spesifikasi dan maklumat yang diperolehi. Rekabentuk yang baru ini dilengkapi dengan ciri pad metatarsal, perlindungan tumit, dan kontor anjal yang membuatkan rekabentuk ini luar biasa. Akhir sekali, reka bentuk ini kemudiannya dianalisis dengan menggunakan FEA dan dibandingkan dengan peraturan rekabentuk ergonomik. Keputusan di akhir laporan ini akan menunjukkan bahawa rekabentuk baru itu dapat dihasilkan.

ABSTRACT

Shoe insole is one of the main component of shoes which design to protect the human feet from pain and agony that felt while wearing shoes. One whom working in standing position has possibilities to get back pain. The solution of the problem is to get a surgery or to make a custom shoe insoles in order to reduce the pain. Thus, the option given is expensive. In order to counter the problems, a solution is suggested which is to design and develop a shoe insole that have feature of ergonomics and flexible while maintaining the aesthetic value on the design. The shoe insole will be made by reusable and green material in order to cut down the cost. The development of the new design proposal is begin with understanding the type of shoe insole available in the market. Besides, the anthropometry of the feet is studied in order to determine the adequate dimension for the shoe insole. The pressure distribution of the foot is examined with the purpose to determine the poor section that suffer the most pressure. Later, a new design is proposed by using the specification and the information obtain. The new design is equipped with metatarsal pad, heel cover and flexible contour which makes the new design extraordinary. Lastly, the design is then analysed by using FEA and compared to the ergonomic design rule. The result will show that the new design is possible to be made.

DEDICATION

I dedicate this report writing especially to my beloved parents and to my whole family. A millions of thanks to them as they gave me full support, and also for my respective Lecture and my supervisor Dr Suriati Binti Akmal, thank you so much for teaching and guided me. I also dedicate this report writing to the ummah of Prophet Muhammad S.A.W. as the project is conducted to show that muslims is able contribute in the world of engineering. Last but not least, I dedicate this for my friends for their support and guidance.

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"In the name of Allah, Most Gracious, Most Merciful"

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TABLE OF CONTENT

Abstrak	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of Content	v
List of Tables	viii
List of Figures	ix
List Abbreviations, Symbols and Nomenclatures	xi
CHAPTER 1: INTRODUCTION	1
1.1 Background	1
1.2 Problem statement	2
1.3 Objectives	3
1.4 Scope	3
CHAPTER 2: LITERATURE REVIEW	4
2.0 Introduction	4
2.1. Anatomy of human foot	5
2.2 Foot type	5
2.3 Shoe insole	6
2.4 Ergonomics	7
2.4.1 Anthropometry	8

2.4.1.1	Footwear sizing system	9
2.5	Flexible	10
2.6	Aesthetic	11
2.7	Computer Aided Drawing (CAD)	12
CHAPTER 3: METHODOLOGY		13
3.0	Introduction	13
3.1	Flow chart	14
3.2	Phase methodology	16
3.2.1	Planning phase	16
3.2.2	Design phase	16
3.2.3	Analyse phase	17
3.3	Material used	18
CHAPTER 4: RESULTS AND DISCUSSION		18
4.0	Introduction	18
4.1	Type of shoe insole	20
4.2	Anthropometry data	21
4.2.1	Force distribution	24
4.3	Design proposal	25
4.3.1	Components of new design proposal	28
4.4	Finite element analysis	30
4.4.1	Analysis on heel area	31
4.4.2	Analysis on metatarsal area	36

4.5	Ergonomic analysis	41
4.6	Discussion	43
CHAPTER 5: CONCLUSION AND FUTURE WORK		44
5.1	Conclusion	44
5.2	Future Work	45
REFERENCES		46
APPENDIX A		
APPENDIX B		

LIST OF TABLES

4.1	The list of pros and contras of flat type and 3 point support type shoe insole	20
4.2	Components description	28
4.3	FEA data for 500N on heel area	32
4.4	FEA data for 700N on heel area	33
4.5	FEA data for 1000N on heel area	34
4.6	Total data of FEA on heel area	35
4.7	FEA data for 500N on metatarsal area	37
4.8	FEA data for 700N on metatarsal area	38
4.9	FEA data for 1000N on metatarsal area	39
4.10	Total FEA data on metatarsal area	40

LIST OF FIGURES

2.1	Type of feet	6
2.2	Insole patent	7
2.3	Example of human body part for anthropometry data collection	9
2.4	The design of ballet shoe insole	11
3.1	Example of FEA analysis	17
3.2	Reuse rubber foam	18
4.1	The Concept Lattice of Automotive Engine	20
4.2	The Visualisation of Class Relations and Attributes	20
4.3	Guide for feet measurement	21
4.4	Standard shoe size for man	22
4.5	Standard shoe size for woman	23
4.6	Image of force distribution on feet	24
4.7	Drawing of proposed design	26
4.8	Exploded view of proposed design	26
4.9	Side view, top view and isometric view of contour section	27
4.10	Detailed drawing of proposed design	28
4.11	Force and fixture applied on the heel	31
4.12	Force and fixture applied on the heel in detailed view	31
4.13	Force and fixture applied on the metatarsal	36
4.14	Force and fixture applied on the metatarsal in detailed view	36

4.15	Heel and arch support on the newly proposed design	41
4.16	Rear foot wedge visualization on the newly proposed design	42
4.17	Metatarsal area on the newly proposed design	42

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CAD	-	Computer Aided Drawing
FEA	-	Finite element analysis

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, there are hundreds of company in shoe making industry which creates various and exquisite design. Shoe is indeed completes one's fashion desire and it would be a loss if without wearing one. Shoe plays an important role in human being lives as it is function to protect the foot from the soil or ground. The shoe was being in human life so long as it was found in a Spanish cave drawing 15 thousand years ago claim by History of Footwear website. The shoe back then was made by the skin of an animal and its wrap the foot. Then, the usage of shoe is also recorded during the Roman Empire. At that moment, the shoe is called '*caliga*' (Gill, 2014). The design of caliga is exposing the toes, had a lattice patterned and heavily nail sole. The shoes at this age represent one's status and comfort is not an important matter to be bother. This situation was changed during the 1800's where the shoe maker does receive complains from traveller about the pain they felt on the foot during travelling (Kaye, 2011). Thus, the issue of comfort is highlighted and people is trying to solve that problem. At 1865, Everett H. Dunbar make a breakthrough by inventing an arch support orthotic (Hayes, 2013). Arch orthotics is a shoe insole that is design like the shape of an arch and it is function to protect the feet from pain. Everett H. Dunbar insert a layer of leather between the insole and outsole of the shoe that is shape like an arch which resemble the shape of a feet (Hayes, 2013). While at 1905, Whitman Brace invent the first full foot orthotic that is made by heavy metal (Hayes, 2013). As the years passing by and the technology has been improved, the arch orthotic is being implemented on most of the shoes in the markets today.

This type of comfort that is felt on arch orthotics shoe insole is important and should be the highlight for the product designer so that the customer feel satisfied with their purchases. In the same time, the feeling of comfort can indicates that there is no pain felt as the customer were wearing them.

1.2 Problem Statement

In the meantime, there is a research conducted by Professor Karen Messing, an ergonomist from the biological sciences department at Quebec University, Canada regarding on the back pain caused by standing too long (Elkins, 2013). She said that most of workers suffered from lower back pain caused by spending most of their time by standing. Occupation like hairdresser, policeman and teachers whom spend most of their working time by standing are likely to have lower back pain. Usually, when the people felt pain they go and meet the doctor. In order to overcome the pain, the alternative to treat are whether to perform a surgery or to purchase an orthotics shoe insole. For the most of the people, the surgery is not a popular option as it is very expensive. In other hand, the consultation for the custom made orthotics is less expensive compared to surgery but the numbers is still far from affordable. Furthermore, the usage of orthotics shoe insole is limited as it doesn't be used daily because of its price tag. The people rather endured the pain for a long time and use the normal shoes that is available in the market which does not equipped with arch orthotics shoe insole. In order to overcome the limitation of lacking of inexpensive arch orthotics shoe insole, this project to enhance proposes the conceptual design of a shoe insole and the material used in making them. As a result, it reduces the agony and discomfort that is faced by the consumer.

1.3 Objective

The main objective as follows:

- i. To develop a conceptual design that have ergonomics and flexibility feature which have an aesthetic value.

1.4 Scope

This research is focusing on the generating new design of the shoe insole. The design of shoe insole is consist of two main objective to be met which are it is must be ergonomics and flexible. The conceptual design must be able to reduce the force acting on the feet while standing and must be shock absorbent which influenced by the material used. Furthermore, the conceptual design must have contour or sections that can be compressed or fold so that it can be classified as flexible and it can fit in average size shoe in Malaysia. The analysis on the materials used does not include in this project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Literature review includes study and research of presented material such as journals, thesis, case studies, technical document, book and online library. Generally, the objective of their view is to analyse critically a portion of a published knowledge through summary, classification, approach used in their project, and any technique that used in their study, review of literature and theoretical articles. This chapter will describe topics that related with the project conducted which are ergonomics, flexible, aesthetic, Computer Aided Design (CAD), design, conceptual design, Finite Element Analysis (FEA), and other relevant topic for this project. These chapters to carry out any approach that can use in drain cover frame design and analysis using Finite Element Analysis method and carry out current product design.

2.1 Anatomy of human foot

Due to the fact of exterior form of the foot, the internal shape of the structure for the foot is actually crucial to develop a footwear. Mainly because, the footwear isn't just to convey the appropriate covering, and also to give mechanical harmony for the individual biomechanics in order to enhance the overall performance of design as well as engineering assistance. This might be bound to some properly understanding regarding the bone structure and also musculature (Vass&Molnar, 1999).

The foot structure is actually organized in order to really support the physical of human, to maintain the stability of the human anatomy, as well as propel one's body throughout their motion. One portion of the foot aids the human body as the another one functions for propel it. When jumping off the countertop onto the floor, the foot propels the entire body away from the countertop and also sustains the force while the body in contacts to the ground.

The foot is divided into three segments:

1. Rear foot or hind foot which composed of the ankle bone and heel bone
2. Midfoot which have five shorts bones and the arch.
3. Forefoot that consist of the metatarsal and the toes (Ozkan, 2005).

2.2 Foot types

Foot type have always been frequently classified through arch height. The arch of the foot is formed simply by bones and it is supported with muscle groups, tendons, as well as ligaments. Arches can be contemplated as high (cavus), average, or perhaps low (planus). The arch height ought to be examined whenever an individual is actually standing with full weight onto the feet, because a flexible foot might seem to have higher arch when there isn't any force positioned on it.

There are three basic foot types that affect the biomechanical needs of the feet.

- a) The average foot possesses normal size arch as well as leaves an imprint which has a flare however demonstrates the forefoot and also heel are associated

through a broad set. The regular foot lands on the exterior of the heel as well as moves inwards (pronates) a little towards shock absorbent.

- b) The flat foot possesses low arch as well as departs an almost total imprint. This is certainly, the imprint appears just like the entire sole of the foot. This particular imprint commonly shows an over pronated foot which hits on the exterior of the heel and also drift inwards (pronates) excessively.
- c) The high arched foot results in an imprint showing a tremendously slim band linking the forefoot as well as heel. A curved, high arched foot is actually in general termed as supinated or perhaps below-pronated foot (Ozkan, 2005).



Figure 2.1: Type of feet. (Etchison, 2009)

2.3 Shoe Insole

A shoe is design with the intention to protect and please the human with providing comfort to the foot while using it. Shoes are also synonym as the icon of fashion. The design of shoes features diverse extremely through time and from tradition to tradition, with look initially being tied to function. Shoes have actually typically been made from wood, canvas or leather, but there are also being made from plastics, rubber, and other petrochemical-derived materials. The design and development of footwear is to provide a covering for the foot while addressing for fashion or style (Goonetilleke, 2003). The parts of a shoe are pretty typical, no matter of the certain design or style of footwear. Insole is the component that is vital and is placed in every shoes ever design in order to provide a protection to the feet while in contact to the ground. Shoe insole is discovered to be made from variety of materials, although many contemporary shoes

have actually soles made from natural rubber, polyvinyl chloride (PVC) or polyurethane substances. The function of shoe insole is to provide cushioning which supposed to attenuate or dampen the impact forces acting on the body during usage (Goonetilleke, 2003).

2.4 Ergonomics

Ergonomics is the application of scientific principles, methods, and data drawn from a variety of disciplines to the development of engineering systems in which men and women perform a significant part (Kroemer, 2001). Whenever designing a product for consumer, designer has to consider assorted influential factors among them are ergonomics and aesthetics which are extremely crucial (Kaljun and Dolsak, 2004). The example of invention of shoe insoles for footwear having improved cushioning and anatomical centering assistance. A medial anatomical centering member is positioned along the medial side of the base and extends from about the front of the arch to the heel (Dalton, Martinez and Hardt, 2006).

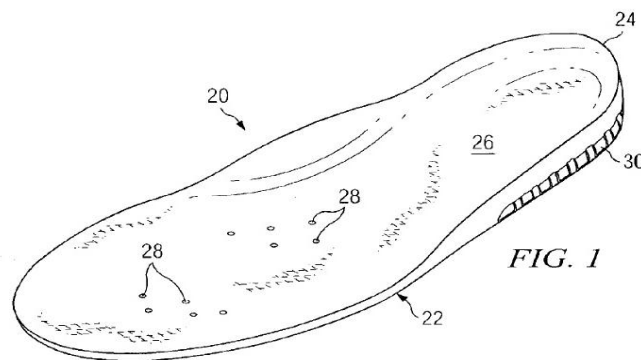


Figure 2.2: Insole patent US 7,107,705 B2 (Dalton, Martinez and Hardt, 2006)

2.4.1 Anthropometry

According to Karl Kroemer, Henrike Kroemer, Katrin Kroemer-Elbert (2001) in their book *Ergonomics: How to Design for Ease and Efficiency* stated that anthropometry is the study of measurement of the human body in design equipment and arrangement of workstation. Anthropometric information features has become relevant when it comes to designing consumer products that involves ergonomic factors. They are utilized to develop design benchmark for heights, clearances, grips and reaches of workplaces and equipments for the function of accommodating the body dimensions of the prospective workforce and also product design (Nursalbiah et al., 2011). The utilization of anthropometric data will enable designers to accommodate a desired component of the potential user population in their designs (Tayyari, 2000). For the Malaysian population, the anthropometry data is influenced by the ethnicity of Malaysian such as Malay, Chinese or Indian (Karmegam et al., 2011). Whenever it involves the designing of product and workplaces, the principles of ergonomic and anthropometric should become a necessary item (Pentikis et al., 2002).

Position					
Standing	Sitting			Others	
Stature	Crown buttock height	Buttock popliteal length	Hip breadth	Hand length	Foot breadth
Eye height	Eye height	Buttock knee length	Shoulder breadth	Hand breadth	Head length
Shoulder height	Shoulder height	Buttock heel length	Elbow breadth	Hand thickness	Head breadth
Elbow height	Elbow height	Elbow grip length		Thumb breath	Head height
Fist height	Popliteal height	Forward grip reach		Forefinger tip breath	Circumference
Vertical grip reach	Thigh thickness	Abdominal depth		Foot length	Weight

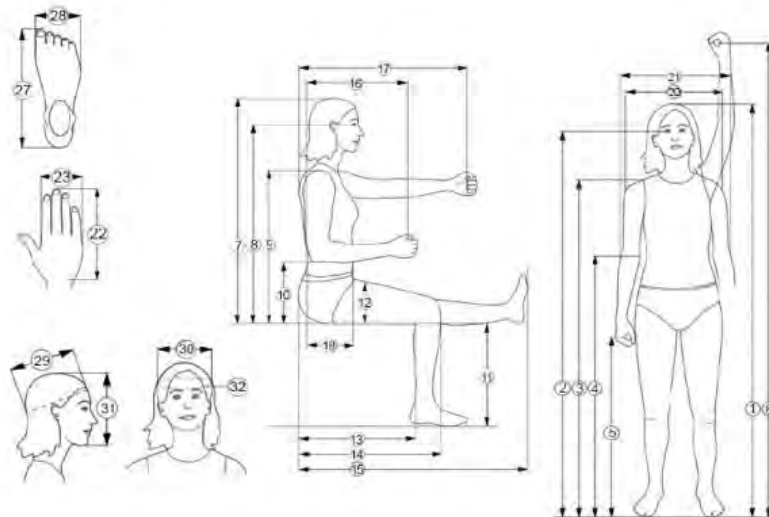


Figure 2.3: Example of human body part for anthropometry data collection (Source Karmegam et al., 2011)

2.4.1.1 Footwear sizing system

The footwear industry offers common measurement ever since the eighteenth century by using the stitch measurement. Craftsmen from the assorted districts had decided to follow the designation of size. However up until the mass manufacture of footwear began during the late of the nineteenth century, the footwear size, plays no important significant to the designation footwear size.

a) French Sizes

The usage of the Parisian stitch simply more than a quarter inch or 6.667 mm long became popular in European countries during Napoleon, at the start of their eighteenth century. However this particular measurement ended up being shortly discover to be insufficiently accurate, and half sizes had been introduced in certain regions. French size 40.5, for instance is actually similar to 11 inches.