



**ESTABLISHING THE DESIGN GUIDELINE OF CUSTOMIZED
INSOLE VIA PRESSURE DISTRIBUTION FOOT PLANAR
EQUIPMENT**

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

by

NORHAZIRAH BINTI LASA

B051310256

940727-01-5458

FACULTY OF MANUFACTURING ENGINEERING

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This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Engineering Design) (Hons). The members of the supervisory committee are as follow:

.....
(Ruzy Haryati Binti Hambali)

ABSTRAK

Lapik kasut adalah salah satu elemen dalam kasut untuk melindungi kaki dan mengelakkan dari sebarang kecederaan. Dilaporkan daripada kajian literatur sebelum ini,, mereka mendakwa bahawa pekerja industri mengalami isu-isu keletihan otot lumbar yang membawa kepada sakit belakang semasa menjalankan tugas mereka. Bagi mengatasi isu ini, literatur mencadangkan bahawa lapik kasut akan dapat mengurangkan risiko keletihan otot yang dapat menyebabkan sakit belakang. Tetapi, hasil kerja yang lepas juga menyatakan bahawa, tiada garis panduan yang khusus untuk menghasilkan kasut keselamatan iaitu yang dapat memberikan tumpuan kepada lapik kasut yang sesuai. Oleh yang demikian, projek ini dijalankan untuk memberikan garis panduan untuk menghasilkan reka bentuk lapik kasut menggunakan “Pressure Distribution Foot Planar Equipment” (F-Scan) yang berfungsi mengukur tekanan antara muka permukaan kritikal dengan gangguan minimum. Struktur fizikal sensor yang mempunyai sensor nipis dan fleksibel dapat menghasilkan bacaan tekanan yang tepat. Terdapat 45 responden yang terlibat dalam pengumpulan soal selidik dan 23 responden menyumbang kepada eksperimen. Responden-responden yang terlibat ialah terdiri daripada pekerja jabatan layup di XYZ Sdn Bhd. Bilangan responden yang menyumbang kepada eksperimen lebih sedikit daripada bilangan responden untuk soal selidik. Hal ini kerana kekurangan alatan eksperimen dan kekangan masa. Soal selidik yang dijalankan adalah untuk mendapatkan latar belakang responden dan beberapa maklumat yang digunakan untuk membangunkan garis panduan reka bentuk lapik kasut. Di samping itu, antropometri kaki digunakan untuk menentukan dimensi yang mencukupi untuk lapik kasut. Selain itu, perisian “CES Edu Pack” digunakan untuk memilih bahan yang sesuai untuk menghasilkan lapik kasut. Setelah menghasilkan garis panduan reka bentuk, pengesahan garis panduan reka bentuk telah dibuat dengan membandingkan taburan tekanan puncak kaki apabila memakai lapik kasut yang sedia ada dan lapik kasut yang direka khusus.

ABSTRACT

The shoe insole is one of the element in the shoe to protect foot and avoid from any injuries. Reported from the previous literatures review they claimed that the industrial workers suffer from lumbar muscle fatigue issues that lead to back pain symptom while performing their job. In order to overcome these issue, literatures suggest that shoe insoles will be able to reduce the health risks. The solution to solve the issue is to improve the structure of insole in the shoe. However, based on the previous work, stated that there are no specific guideline to produce the insole for safety shoes focusing on customized insole. According to the issue, this project which is design guideline of customized insole via foot planar equipment (F-scan) will construct the guideline to ease the process of customized insole. Pressure distribution foot planar equipment have been chosen as the main measurement to this project. The function is to measure the critical surface interface pressure with minimal interferences. The physical structure of sensor which is have thin and flexible sensor can provide highly accurate of pressure reading. There are 45 of respondents involved to the collection of questionnaires and 23 of respondents contributed to the experiment. The respondents are coming from XYZ Company Sdn Bhd of department layup. The number of respondents for experiment is smaller than collection of questionnaires because of the limitation of equipment and time. The questionnaires is developed to get the background of the respondents and some of information that used to developed the design guideline of customized insole. Besides that, the anthropometry of the feet is used in order to determine the adequate dimension for the shoe insole. Moreover, the selection of material to produce the customized insole is used CES Edu Pack software to ensure right selection of material. After, constructing the design guideline, the validation of design guideline have been made by comparing the peak pressure distribution of foot when wearing the existing insole and customized insole. The peak pressure after using the customized insole is lower than using existing insole.

DEDICATION

To my beloved family member
my beloved father, Lasa Bin Nandiman
my appreciated mother, Sabariah Binti Zainal
and my adored brothers Muhamad Adi, Muhammad Najib, Mohd Musa and Mohd Shukri
for
giving me moral support, money, cooperation, encouragement and also understanding
along this project.

Thank You and Love u all so much.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

3D	Three Dimension
CAD	Computer Aided Design
FEA	Finite Element Analysis

LIST OF EQUATION

2.1 Equation of Pressure

CHAPTER 1

INTRODUCTION

This chapter gives a brief introduction of final year project about establishing the design guideline of customized insole via pressure distribution foot planar among the composite manufacturing industry. In addition, the aim and objectives of the study, the research scope as well as the project planning, rationale of the study and thesis outline are also presented in this chapter.

1.1 Background of the Project

According to Lambert (2016), a footwear is one of the important protections for people to cover their foot against condition of the environment, usually regarding ground, textures and temperature. Long time ago, there are some of examples for the evolution of shoes that can be seen as history. During the evolution of Ice Age, people who wore simple leather boots was called as Cro-Magnons. The boots are covering the feet from the cold was essential as they lived during an ice age. While in Egypt shoes were not necessary to wear leather boot because of the contra climate with Ice Age. Most of the Egyptian preferred to be barefoot almost of the time and sometimes wore sandals made from papyrus and well-off Egyptians wore leather sandals (Lambert, 2016). In the research from History of Footwear website, the shoe was being in human life so long as it was found in a Spanish cave drawing 15 thousand years ago. 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'. The 'caliga' allowed for the free passage of air to the feet as the design was opened unlike the modern military boot based on the uncomfortable 'caliga' (Gill, 2014). The evolution of footwear was increasing from sandal to present-day sport

shoes that are marvels of engineering (Lambert, 2016). This situation was changed starting the 1800's where the shoe maker does receive complains from traveler about the pain they felt on the foot during travelling (Kaye, 2011). Thus, the issue of comfort is highlighted and people are trying to solve that problem. In 1865, Everett H. Dunbar make a breakthrough by inventing an arch support orthotic (Hayes, 2013). The individuals with discomfort and/or abnormal skeletal alignments in the structures of the lower extremity have been recommended to use the arch support orthotics. It is because the arch support is really important to make sure the shoe comfy to wear. Lately the promoting of semi-rigid orthotics becoming more increased especially for workers involved the prolonged standing at their workplace (Kelaher *et. al*, 2000). Then at 1905, Whitman Brace invent the first full foot orthotic that is made by heavy metal (Hayes, 2013). When the development of technology have been increased, there are many of shoe's industry implemented the concept of arch orthotics in the market. Time by time, people realized that, insole is one of the important criteria should be needed in the shoe to avoid from the injuries happened and it is a crucial to have the guideline of defining the criteria of developing insoles. Moreover, the insole can be used to treat Low Back Pain (Landorf, 2001), but there is no strong guideline for used in clinical practice, further investigation is warranted.

Pressure distribution have been chosen to be the main measurement to measure the peak pressure of the feet. The pressure distribution that used in this study is from Tekscan. Based on Tekscan (2016), the Tekscan is innovative pressure distribution systems can measure the static and dynamic events. These system is able to measure the critical surface interface pressure with minimal interferences. The physical structure of sensor that have thin and flexible sensor can provide highly accurate of pressure reading. The custom pressure sensor also can be shaped to meet specific application requirement. These measurement have been trusted to be used in this study because of the previous customer feedback for Tekscan product. Reported that the world renowned podiatrist Howard Dananberg, DPM was used pressure distribution to analyze the effectiveness of this insolia insole. The insolia insole supplements is used to change the weight from the limit of larger area and move from the ball of foot and transmitting back to the heel. It can help to stop the foot from moving forward within the shoe. The insolia can improve the stability, body alignment and overall posture and comfort ability of the user (Tekscan, 2016).

In order to solve this issues, this project intends to develop the design guideline of customized insole for composite manufacturing company. Therefore, anthropometry data, questionnaires and pressure distribution will be used as the method to develop the guideline and this database can guide and suggest the company in design and developing customized insole as well accordingly to solve the problem of foot among worker. In order to overcome the limitation of lacking of inexpensive arch orthotics shoe insole, this project to enhance proposes the design that considered the ergonomic aspects, material used, profile of foot, flexibility and aesthetic aspects fused in making them. As a result, it reduces the pain and discomfort that is faced by the workers.

1.2 Problem Statement

Based on the factory visit, XYZ Company Sdn Bhd used almost 90% of manual handling in their working activities in the production line to manufacture the product. The movement of the workers in the production line includes a lot of prolonged standing. Therefore, the working activity will produce forces which are beyond the normal range that body can physically manage and this will lead to pain and injury. In addition, reported that one of the Protective Personal Equipment (PPE) to ensure any accident happened is with the usage of the safety boots amongst the workers. However, most workers do not aware about the wearing safety shoes because they are not realized the important role the shoes as long as the shoes can protect their foot from injury. Besides, injury also can come from the shoes that they wear every day doing the job (XYZ Company, 2016). Wearing shoes with a wrong size or less appropriate could cause users with uncomfortable and bring in various problems.

In addition, commercial shoes that are now available in the market does not meet the standards of personalized footwear. These factors will affect the health conditions of workers as well reducing the performance and quality of the workers. Reported from the previous literature review they claimed that the industrial workers survive from lumbar muscle fatigue issues while performing their job. In order to overcome these issues, literatures suggest that interventions including the use of floor mats, sit-stand workstation chair, shoes, shoe insoles, shoe inserts and hosiery or stockings will be able to reduce the health risks.

One of the methods to ensure improvement of performance, increasing the comfort and reducing the risk of injury is by implementing the sole of the foot. Based on the previous work, it is stated that there is no specific guideline to produce the insole for safety shoes focusing on a customized insole. According to Crabtree *et al.* (2009), they have established the paper that focused on the making of sports insoles and delivers a methodology for the design and manufacture of a customized symptom-specific sports (3S) insole. Other than that, refer to the study from Tan *et al.* (2015), the customized insole has been used to reduce the risk of developing Low Back Pain (LBP) issues among Western industrialized. Therefore, the goal of this project is to suggest a product intervention to be used by the workers in order to reduce the lumbar fatigue. Then, this goal will be achieved by providing the design guideline of a customized insole via pressure distribution foot planar equipment. This guideline will be useful databases for engineers, designers and researchers in defining and providing information of design customized insole.

1.3 Objective

The main aim of the project is to develop the design guideline to customize the insole via pressure distribution foot planar. The objective of this project are:

- a) To identify all of the criteria needed to customize the insole.
- b) To analyse the peak pressure on the customized insole by using pressure distribution F-scan sensor.
- c) To establish the design guideline, test and analyse the customized insole according to the constructed design guideline.
- d) To validate the design guideline.

1.4 Scope

This project will focus on the design guideline to customize the insole by using pressure distribution foot planar. During the process of collecting and analysing the data, there are several scope the project as a guide. The project scope for this project are:

- a) Respondents that involved in this study are from department of PM3 that doing the layup activities.
- b) The measuring process of parameter related to the foot included the anthropometry measurement and pressure distribution.
- c) There are 45 of respondents are involved in the collection data of questionnaire.
- d) The sample are from four of population which are underweight, normal, overweight and obese.
- e) The customized insole will analysed by using Finite Element Analysis.
- f) All of the result of the collected data will be analysed by using Microsoft Excel and SPSS software.

1.5 Project Planning

In conducting this project, there are the list of task is constructed in the Gantt chart to ensure all the related tasks can be finished in respective time. A Gantt chart is usually used to manage the project and it is one of the most popular and useful methods of display activities displayed against time. There are two of important things that highlighted in the Gantt chart, first the list of activities on the left chart and second the time scale on along the top of chart. Each activity is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the activity (Gantt chart, 2016). The Gantt chart of this project can be seen at Appendix A and B.