



DESIGN OF PERSONALISED INSOLE FOR PRODUCTION LINE INDUSTRIAL WORKERS VIA LEVEL OF PAIN AND PRESSURE DISTRIBUTION DATA

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.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) with Honours. The members of the supervisory committee are as follow:

.....
(Puan Ruzy Haryati Binti Hambali)

ABSTRAK

Tujuan kajian ini untuk mengkaji lapik dalam kasut persendirian terhadap pekerja industri. Lapik dalam kasut adalah salah satu komponen utama kasut yang merupakan reka bentuk untuk melindungi bahagian bawah atau pangkal kaki daripada mengalami kesakitan. Lapik dalam kasut juga memberi keselesaan semasa berjalan atau berlari dan bekerja. Masalah utama projek ini adalah untuk menyiasat isu-isu sakit belakang di kalangan pekerja barisan pengeluaran perindustrian. Postur berdiri adalah salah satu faktor yang menyumbang kepada sakit kaki dan mempunyai kemungkinan untuk mendapatkan sakit belakang. Terdapat beberapa penyelesaian untuk mengatasi kesakitan iaitu membuat lapik kaki khas tetapi kos pembuatan agak tinggi. Kajian ini mencadangkan penyelesaian untuk menangani masalah ini dengan mereka bentuk dan membangunkan lapik dalam kasut peribadi baharu melalui Additive Manufacturing (AM). AM adalah proses gabungan bahan-bahan untuk mencipta objek daripada model 3D CAD secara berlapis-lapis. Pembangunan cadangan reka bentuk baru adalah bermula dengan memahami tahap kesakitan berdasarkan kawasan kaki dan taburan tekanan untuk menjalankan bahagian yang menyumbang sakit yang tinggi. Selain itu, antropometri kaki dikaji khusus mengikut responden untuk menentukan ukuran yang sesuai untuk lapik dalam kasut. Kemudian, reka bentuk baru dicadangkan berdasarkan pengumpulan data. Reka bentuk baru akan dianalisis menggunakan FEA untuk mengetahui tekanan. Lapik dalam kasut yang baharu dihasilkan dan diuji dengan menggunakan taburan tekanan dan Electromyogram (EMG). Hasil kajian menunjukkan bahawa dengan menggunakan lapik dalam kasut baru, berlaku pengurangan taburan tekanan, tetapi malangnya hasil daripada EMG menunjukkan peningkatan apabila menggunakan lapik dalam kasut yang baru.

ABSTRACT

The aim of this study is to design the new personalised insole for industrial workers. Shoe insole is one of the main component of shoes which is design to protect the underside or base of foot from pain. The insole provide comfort during walking or running and working activity. The problem statement of this project is to investigate back pain issues among the production line industrial workers. Standing posture are one of the factor to cause pain of the feet and has possibility to get back pain. There are some solution to overcome the pain that is to create a custom insole but the cost are quite high. This study is suggesting solution to counter the problem which is to design and develop new personalised insole using Additive Manufacturing (AM). AM is the process of joining materials to create an objects from the 3D CAD model layer upon layer. The development of the new design proposal is begin with understanding the level of pain based on area of foot and pressure distribution to carry out the section that contribute the highest pain area. Besides, the anthropometry of the foot is studied specifically according to the respondent in order to determine the suitable measurement for shoe insole. Later, a new design is proposed based on the data collection. The new design was analysed using FEA to find out the pressure. The new design personalised insole is fabricated and validate by using pressure distribution and Electromyogram (EMG). The result shows that by using a new personalised insole, the pressure distribution decrease, but unfortunately the result of EMG increase when using new personalised insole.

DEDICATION

To my beloved family member
my beloved father, Alwi bin Sulong
my appreciated mother, Aaini binti Kesot
and my adored sister and brother Muhamad Shawal, Madeeha, Ramadhan and Junainah
for giving me moral support, money, cooperation, encouragement and also understanding
along this project.

Thank You So Much and Love You All Forever

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TABLE OF CONTENT

Abstrak	i
Abstract	ii
Dedication	iii
Acknowledgement	iv
Table of content	i
List of tables	v
List of figures	vi
List of abbreviations and symbol	viii
CHAPTER 1: INTRODUCTION	1
1.1 Project Background	1
1.2 Problem Statement	3
1.3 Objectives	4
1.4 Scope	4
1.5 Project Planning and Execution	5
1.6 Rationale of the Project	5
1.7 Organization of the Thesis	6
CHAPTER 2: LITERATURE REVIEW	7
2.1 Back Pain	7
2.1.1 Chronic Low Back Pain	8
2.2 Overview of Footwear and Insole	9

2.3	Fabrication of Personalised Insole via Additive Manufacturing Technology	10
2.3.1	Additive Manufacturing	10
2.4	Anthropometry	12
2.5	Personalised of Insole	15
2.6	Related Researches Focus on Fabrication of Personalised Insole using AM	18
2.7	Summary	19
 CHAPTER 3: METHODOLOGY		 20
3.1	Project Planning	20
3.1.1	Flowchart	21
3.2	Relationship between Methodology and Objectives	23
3.3	Data Gathering	24
3.3.1	Questionnaire Development	24
3.3.1.1	Literature Review	24
3.3.1.2	Pilot Study	25
3.3.2	The questionnaire design	25
3.4	Material Selection	30
3.4.1	Acrylonitrile Butadiene Styrene (ABS)	31
3.4.1.1	Properties of Acrylonitrile Butadiene Styrene (ABS)	31
3.5	Workers' Foot Pressure Using F-san Sensor	32
3.5.1	Subject for the F-scan Sensor	33
3.5.2	F-scan Experimental Procedure	34
3.6	Design Process using SolidWorks Software	35
3.6.1	SolidWorks 3D CAD	36
3.7	2D Drawing	36
3.7.1	Finite Element Analysis (FEA) using SolidWorks Simulation	36
3.8	Fabrication Process using AM Machine	37

3.9	A summary of Method Used	38
CHAPTER 4: RESULTS AND DISCUSSIONS		39
4.1	Result and Analysis of Questionnaires	39
4.1.1	Gender of Respondents	40
4.1.2	Age of the Respondents	41
4.1.3	Height and Weight of Respondent	42
4.1.4	Working Position	43
4.1.5	Shoe Size of Respondent	44
4.1.6	Level of Pain and Satisfaction of Insole	45
4.1.6.1	Level of pain and Satisfaction of Insole on the Left Foot	45
4.1.6.2	Level of pain and Satisfaction of Insole on the Right Foot	46
4.2	Result and Analysis of Foot Profile	47
4.2.1	Data Collection on Force under Foot	47
4.2.2	Analysis on Top Five Subject	50
4.3	Design and Development of Personalised Insole	54
4.3.1	Result of Finite Element Analysis (FEA) Simulation	56
4.3.1.1	Result of FEA Simulation	57
4.3.1.2	Von Mises Stress of Design 1	58
4.3.1.3	Von Mises Stress of Design 2	59
4.3.1.4	Von Mises Stress of Design 3	60
4.3.2	Fabrication of Personalised Insole using AM Machine	61
4.3.3	Validation of the Personalised Insole	61
4.3.4	Validation using F-scan sensor	62
4.3.5	Validation using Electromyogram (EMG)	65
4.3.5.1	Validation Result of Electromyogram (EMG)	66

CHAPTER 5: CONCLUSION AND RECOMMENDATION	68
5.1 Conclusion	68
5.3 Recommendation	69
5.2 Sustainability	69
5.3 Complexity	70
5.4 Long Life Learning	70
REFERENCES	72
APPENDIX A	75
APPENDIX B	76

LIST OF TABLES

Table 3.1: Methods used to achieve objective	23
Table 3.2: Mechanical properties of ABS	31
Table 3.3: Eco properties of ABS	32
Table 3.4: Summary of equipment and software	38
Table 4.1: Percentage gender of respondent	40
Table 4.2: Percentage of age of respondent	41
Table 4.3: Percentage BMI of respondent	42
Table 4.4: Working position of respondent	43
Table 4.5: Percentage shoe size of respondent	44
Table 4.6: Percentage level of pain on left foot	45
Table 4.7: Percentage level of pain on right foot	47
Table 4.8: The top five subject with highest peak pressure	52
Table 4.9: Type of personalised insole	55
Table 4.10: Material Properties of personalised insole	57
Table 4.11: Stress result of Design 1	58
Table 4.12: Stress result of Design 2	59
Table 4.13: Stress result of Design 3	60
Table 4.14: Pressure distribution of both insole	63
Table 4.15: Pressure distribution based on colour scale	64
Table 4.16: Histogram result of EMG	67

LIST OF FIGURES

Figure 2 1: The part development of AM	10
Figure 2.2: An example of anthropometry measurements of standing and sitting position	14
Figure 2.3: The measurement of foots in standing position	14
Figure 2.4: An example of foot profiling measurement that scan by using 3D scanner	15
Figure 2.5: An example of lateral wedge insole	16
Figure 2.6: Three special insoles was used on the special footwear	17
Figure 2.7: Amfit system were used for development of insole	18
Figure 3.1: Research Process Flow Chart for the Project	22
Figure 3.2: Illustrate the questionnaire structures from first part to the last part	27
Figure 3.3: Illustrate the questionnaire structures from first part to the last part (cont.)	28
Figure 3.4: Illustrate the questionnaire structures from first part to the last part (cont.)	29
Figure 3.5: An example of ABS material	30
Figure 3.7: Texan sensor ready to operate	32
Figure 3.6: Sensor attach to the insole	32
Figure 3.8: An example of the subject for F-scan sensor	33
Figure 3 9: Data Texan were taken	33
Figure 3.10: An example of interface of SolidWorks FEA Analysis for insole	37
Figure 4.1: Graph of gender of respondent	40
Figure 4.2: Graph of age of respondent	41
Figure 4.3: Graph of BMI of respondent	42
Figure 4.4: Graph of working position of respondent	43
Figure 4.5: Graph of shoe size of respondent	44
Figure 4.6: Graph of level of pain on left foot	45
Figure 4.7: Graph of level of pain on right foot	46
Figure 4.8: Graph of peak pressure of the subject on the left foot	48

Figure 4.9: Graph of peak pressure of the subject on the right foot	48
Figure 4.10: Graph of peak pressure of the top five highest pressure	49
Figure 4.11: An example of foot profile on F-Scan analysis	50
Figure 4.12: Pressure Indicator of F-Scan Software	51
Figure 4.13: An area of insole	54
Figure 4.14: FEA simulation processes	56
Figure 4.15: Model reference of the personalised insole	57
Figure 4.16: Simulation of Design 1	58
Figure 4.17: Simulation of Design 2	59
Figure 4.18: Simulation of Design 3	60
Figure 4.19: New personalised insole	61
Figure 4.20: Graph of pressure distribution on left foot	62
Figure 4.21: Graph of pressure distribution on right foot	63
Figure 4.22: Validation of EMG on selected muscle	65
Figure 4.23: EMG amplitude of current insole	66
Figure 4.24: EMG amplitude of new personalised insole	66

LIST OF ABBREVIATIONS AND SYMBOL

FEA	Finite Element Analysis
AM	Additive Manufacturing
LBP	Lower Back Pain
FS	Facet Syndrome
EMG	Electromyogram
ASTM	American Society for Testing and Material
FDM	Fused Deposition Modelling
EKAM	External Knee Adduction Moment
EVA	Ethylene Vinyl Acetate
CAD	Computer Aided Design
CAM	Computer Aided Machine
STL	Stereolithography
FO	Foot Orthoses
ABS	Acrylonitrile Butadiene Styrene
UV	Ultraviolet
SOP	Standard Operation Procedure
CTRM	Composite Technology Research Manufacturing

CHAPTER 1

INTRODUCTION

This chapter basically provides a concise introduction to this project to design and develop personalised insole to the industrial workers, together with the indication of the main issues and their applications. In addition, the problem statement, objectives and scopes will also discussed. Project planning and execution, rationale of this project and organization of the thesis will also include in this chapter.

1.1 Project Background

Insole is an interior layers inside a shoe that provide additional comfort and supports the underside of the base. Insole has been used extensively around the world for the same purpose, come in many shapes, sized and used to fit a variety of different foot types. The functionality of the insole is to provide shock and foot sweat absorption from walking or running activities. Generally, the insole can be removed easily and replace with another insole that come separately for more comfort. There are lots of the type of shoes that used insole such as sneakers, formal shoe, sport and boots. Nowadays, the insole contributes a lot of changes to get a healthy life. As a sport shoe, it could provide maximum comfort to the user because sport is one of the outdoor activities and rugged. The insole of the sport shoe also required the arch shape of foots that control the leg and pelvis while doing sport activities. At this stage, the sole is one of the parts of the shoe that is very important for comfort and stability (Dessing, *et al.*, 2014).

In relation to working situation, the safety shoe or boots are preferably prepared for each and every company and every of their workers specifically in the production line. This is because to ensure the safety of worker's foot and it is an effective way to protect the foot from any harm. The safety shoes mainly avoid from slippery with respect to safety and balance performance in order to perform job (Kim, 2016). Generally, insoles were different between safety shoes and sport shoes. Safety shoes focus more on outside part of the shoe and this is where the problems arise among the workers when the foot of the workers developed acute aches and sore feet due to the usage of the less effective insoles. These causes also lead to changes of leg postural and musculoskeletal disorders (Caravaggi, *et al.* 2016).

Furthermore, according to M.Ogon (2000), the use of shoes and insole materials could cause the shock transmission to the spine if the material are not suitable. This study stated that they concerned about the insole that may having low shock absorbing behaviour. Reported that the use of proper shock absorbing insole was one of beneficial way in reducing and treating the low back pain of the users due to the material of the insole. Suggested that proper selection of shoes and shoes insole could reduce external and internal forces around the lumbar spine.

In order to solve the problem, this project conducted to design and develop personalized insole based on peak pressure data and anthropometry of the production line workers that has been collected. The main purpose of the development of this personalized insole expecting to help in improving the lumbar muscle fatigue that occurred to the workers in the production line. This personalized insole develop new level of usage of insole which this insole can be only wear individually whereby each design of personalized insole based on individual anthropometric data and the individual foot profile of the workers. This is a step closer to reduce the lumbar muscle fatigue and assist workers to increase their working productivity without any issues of medical sickness and absenteeism.

1.2 Problem Statement

From the previous researches and literature review, researchers found that the workers suffer from lumbar muscle fatigue issues while performing their job causes from multiple working activities include prolonged standing and sitting, awkward position, heavy lifting and repetitive movement in their workplace (Lehner *et al.*, 2017). In addition, reported that this issue came from the shoes itself whereas the shoes that the worker is wearing was not suitable based on their structure of the insole. The flat shoe can create an awkward leg to stretch in which affects the posture of the prolonged foot. During the working activity, lots of movement occurred and produced force which are beyond the normal range that body can physically manage that leads to injury (CTRM, 2016). Beside, wearing shoes with a wrong size or less appropriate size and contour can cause users with uncomfortable and bring in various problems.

From the site visit to the ABC Company Sdn. Bhd, interview session was conducted and find out that the shoes that are available now does not meet the requirement of personalized footwear. Most workers tend to ignore the importance of wearing the safety shoes due to the awareness and attitude for not prioritising this important role of the shoes. They consider that the usage of shoes just to protect their foot from any injuries. The workers also does not realised that this injury occurred from the shoes that they wear every day while doing the daily routine job (Department of HSE ABC Company Sdn. Bhd, 2016). Resulting from here, these factors will affect the performance and quality of the workers and health issues. In aerospace manufacturing industry, it is essentially important to achieve the fast and quality of production, decrease the health issues and quality of life of the workers. The sole of the foot is the primary method of supporting and propelling the body which is ensuring correctly supported is critical to improving performance, increasing comfort and reducing the risk of injury. Therefore, the goal of this research is to suggest product intervention to be used by the workers in order to reduce the lumbar fatigue. This will be achieved by design and develop personalized insole based on anthropometric, profile and pressure distribution of the respondents.

1.3 Objectives

The principal aim of this research is to design and develop the personalised insole in order to reduce muscle fatigue issues among an industrial workers.

The objectives of this research study are as follow:

- i. To investigate the back pain issues among the production line industrial workers
- ii. To design and develop personalised insole based on the peak pressure distribution
- iii. To test, analyse and validate the proposed design of personalised insole

1.4 Scope

The focus of the research is to overcome back pain problems that happened in an aerospace manufacturing, ABC Company Sdn Bhd. Based on the research, new design of insole is an essential to be created to replace the available insole that currently not suitable to the workers of the ABC Company workers. The conceptual design must be able to follow the structure of the personal foot which is leading to the comfort and ergonomic. Furthermore, the conceptual design of the insole depends on the pressure distribution profile and anthropometric data of the ABC Company Sdn. Bhd. Workers. Pressure distribution and anthropometric data represent an specific individual data including the pressure, contour, sections, size and shape that can be compressed that can lead to the personal insole of each worker in the ABC Company Sdn. Bhd.

In order to collect the data, survey and questionnaires also be used to find out the foot problem of the respondents. This method purposely to identify the level of pain at body parts and satisfaction of existing insole. All data that collected from Department of HSE ABC Company Sdn. Bhd. will be analyse in order to develop prototyping of the personalised insole. SolidWorks software will be used as a main designing software to create 3D solid modelling of personalised insole. The prototyping of personalised insole will be focus on design analysis using Finite Element Analysis (FEA) to determine the pressure distribution of insole Last but not least, the fabrication of the personalised insole will use Additive Manufacturing (AM) system approach to get the prototype of the product based on material

selection by using CES Edupack software to find the suitable material. In order to validate the data, testing and analysis process are conducted through experimental and questionnaires.

1.5 Project Planning and Execution

In this project, all task and activities of the project are listed on the Gantt chart and the time to finish of each task are also consider in the chart in order to make sure the task will be finish on time. This project schedule is presented in Appendix A.

1.6 Rationale of the Project

The rational of the research is too mainly to help the both party. The workers of the ABC Company and the company itself. With the intervention of this personalised insole of the safety boots that we suggest, optimistically can reduce and overcome all the muscle fatigue issues that caused from their working activities, muscle activities and the pressure distribution of the foot. It can overcome the back pain issues by design and developing personalised insole to their safety boots in order to improve the daily working activities of the workers. Hence, the new personalised are develop as well improve the quality of the work of the workers lead to the increasing the productivity of the company.

1.7 Organization of the Thesis

This project thesis is comprised of further four chapters as follows:

- Chapter 2. Literature Review: this chapter conducted by using contextual investigations, specialised report, book, article and online library. This chapter reviews the previous project to find out the expected result. The important characteristic discuss in this chapter is ergonomics, additive manufacturing, an anthropometry and back pain.
- Chapter 3. Methodology: this chapter describes the method involved to develop new personalised insole based on data gathering. The process flow of the project will be determine in this chapter.
- Chapter 4. Results and Discussion: presents and discusses the result of survey analysis, anthropometry data analysis, Finite Element Analysis (FEA), pressure distribution and validation of the experimental. The process of product development from design phased until final phase which is describe detailed in this chapter.
- Chapter 5. Conclusion and Recommendation: summarises and comprise the overall findings, discussion of the project and the recommendation for future works.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the research and study are conducted by using contextual investigations, specialised report, book, article and online library. This chapter is to review and to explore the process of the existing research about this project and how the project was conducted until getting the expected result. The details of the study are covered in this chapter and will describe topics that related to the project conducted includes; footwear, ergonomics, additive manufacturing, anthropometry and back pain.

2.1 Back Pain

Generally, one of the problem that are concerning by the industry of their workers come from the back pain issue. This is because back pain has contribute the worker of the factory less productive which is lead to the waste of time of production and quality of the work. This issue has been an extended study to improve the issue of back pain but it requires extensive improvement due to the changes of the workstation and workers. Back pain may triggered from the bad posture or position such as sitting or standing, bending awkwardly and lifting incorrectly. There are also other causes of back pain which is come from the overstretching, overusing the muscles and pushing or pulling heavy objects. There are types of back pain that will be discussed in sub-chapters below.