

**DESIGN AND DEVELOPMENT OF A HAND MASSAGE DEVICE FOR BLOOD
DONATION PROCESS**

MOHD FAHRI BIN ABD GHAFAR

UNIVERSITI TEKNOLOGI MALAYSIA

**DESIGN AND DEVELOPMENT OF A HAND MASSAGE DEVICE FOR BLOOD
DONATION PROCESS**

MOHD FAHRI BIN ABD GHAFAR

**A dissertation submitted as partial fulfillment of the requirement for the Degree of
Master of Engineering (Mechanical – Advance Manufacturing Technology)**

**Faculty of Mechanical Engineering
Universiti Teknologi Malaysia**

JUNE 2014

*Dedicated to my wife, families, lecturers and friends
Thank you for your support and inspirations
You all are everything to me
May Allah bless all of us...*

ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah S.W.T for showing me the right direction, gave me the strength and allowed me to complete this project as required. I would like to thank my project supervisor, Prof. Dr. Safian Bin Sharif for being patient and helpful throughout the project implementation. His advices, encouragement and assistance will be remembered. Many thanks to all students from Industrial Mechatronic Programme Kolej Kemahiran Tinggi MARA Balik Pulau for their valuable assistance. I am also grateful to everybody who has contributed in this project directly and indirectly.

May Allah bless us.

ABSTRACT

Blood collection center all over the world face the challenge of maintaining a sufficient supply to balance the demand for blood products. Besides the more severe donor selection criteria, the aging population and natality rate are the factors which influence the pool potential donors and cannot be easily changed. Continuous donor recruitment and retention are essential to maintain the nation's blood supply and to ensure the ability to meet future needs. In this study, a systematic approach is used to design and build a hand massage device for blood donation process. The design and development is based on standard procedure suggested by Karl Ulrich Steven Eppinger. Quality Function Deployment approach is used to define the customer needs or requirements and translating into specific plans to produce product to meet those needs. The main elements in the prototype include the vibration system, heat element system and sensing system. The prototype was tested during the blood donation campaign that organized by Kolej Kemahiran Tinggi MARA in March 2014. Result shows that the recommendation from all respondent agreed that the developed prototype device is suitable to be used by the donor during blood donation process in order to improve the amount and increase the confident level. Investigation also showed that the prototype is able to reduce the donation time more than 85% as compared to without using any device during the blood donation process.

ABSTRAK

Pusat pengumpulan darah di seluruh dunia menghadapi cabaran untuk mengekalkan bekalan yang cukup untuk mengimbangi permintaan bagi produk darah. Selain kriteria pemilihan penderma yang lebih teruk, penuaan penduduk dan kadar kelahiran adalah faktor-faktor yang mempengaruhi penderma yang berpotensi dan ia tidak mudah diubah. Pengambilan pendermaan secara berterusan dan penyimpanannya adalah penting untuk mengekalkan bekalan darah negara dan juga memastikan keupayaan untuk memenuhi keperluan pada masa hadapan. Dalam kajian ini, pendekatan yang sistematik digunakan untuk merekabentuk dan membina sebuah perantiurut tangan untuk proses menderma darah. Rekabentuk dan pembangunan adalah berdasarkan kepada prosedur standard yang dicadangkan oleh Karl Ulrich Steven Eppinger. Pendekatan Pertukaran Fungsi Kualiti digunakan untuk menentukan keperluan pelanggan dan menterjemahkan ke dalam rancangan khusus untuk menghasilkan produk yang memenuhi keperluan tersebut. Elemen-elemen utama dalam prototaip termasuk sistem getaran, sistem elemen haba dan sistem penderia. Prototaip diuji semasa kempen derma darah yang dianjurkan oleh Kolej Kemahiran Tinggi MARA pada Mac 2014. Keputusan menunjukkan bahawa cadangan daripada semua responden bersetuju bahawa peranti prototaip dihasilkan adalah sesuai untuk digunakan oleh penderma semasa proses derma darah bagi meningkatkan jumlah amaun dan meningkatkan tahap keyakinan. Siasatan juga menunjukkan bahawa prototaip mampu mengurangkan masa menderma iaitu lebih daripada 85% berbanding tanpa menggunakan mana-mana peranti semasa proses derma darah.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE PAGE	i
	DECLARATION OF SUPERVISOR	ii
	DECLARATION OF AUTHOR	iii
	DEDICATION	iv
	ACKNOWLEDGEMENT	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE OF CONTENT	viii
	LIST OF FIGURES	xi
	LIST OF TABLES	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTION	1
	1.1 Background of Problem	1
	1.2 Problem Statement	2
	1.3 Objectives	3
	1.4 Scope of Study	3
	1.5 Organization of the Report	4

2	LITERATURE REVIEW	5
2.1	The Circulatory System	5
2.1.1	The Heart	6
2.2	Blood	8
2.2.1	Blood Groups	9
2.2.2	Blood Components	11
2.3	Blood Donation Process	14
2.3.1	Blood Donation Procedures	15
2.3.2	Ideal Donor	16
2.4	Massage Therapy	17
2.4.1	Benefits of Hand Massage	19
2.5	Product Design and Development	20
2.5.1	Identifying customer needs	23
2.5.2	Establishing Target Specifications	24
2.5.3	Concept Generation	25
2.5.4	Concept Selection	26
2.5.5	Setting Final Specifications	27
2.5.6	Design Process	27
2.5.7	Modeling and Prototyping	28
2.6	Quality Function Deployment	28
3	RESEARCH METHODOLOGY	32
3.1	Research Planning	32
3.2	Preliminary Study	34
3.3	Available Concept of Hand Massage Machine	40
3.4	Overview on the Patent Search	42
3.5	Data Gathering	47
3.5.1	Method of Gathering Raw Data	47
3.5.2	Respondent Population Research	48

3.5.3	Sample Size	48
3.5.4	Data Collected	49
3.5.5	Preliminary Results	49
3.5.6	House of Quality – Customer needs result	54
3.6	Concept Generation	56
3.7	Concept Selection	59
3.8	Summary	61
3.8.1	Sensing System	61
3.8.2	Vibration System	66
3.8.3	Heat Element System	68
4	RESULT AND DISCUSSION	69
4.1	CAD Model and Drawing	69
4.2	Evaluation on the Feedback of the Prototype	71
4.3	Prototype Testing	76
4.4	Prototype Costing	79
5	CONCLUSION	81
5.1	Conclusion	81
5.2	Future Recommendation	82
	REFERENCES	83
	APPENDICES	87

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	The Heart	7
2.2	Picture of Blood	9
2.3	Blood Groups Matched	10
2.4	Blood Components	12
2.5	Blood Donation Process	14
2.6	Hand Massage	18
2.7	Hand Reflexology Chart	18
2.8	Product Design and Development	20
2.9	Basic Phases Quality Deployment	30
3.1	Research Flow Chart	33
3.2	Statistic Blood Donation in Malaysia	34
3.3	Statistic Blood Donation in Pulau Pinang	35
3.4	Number of new donors in Malaysia	36
3.5	Number of new donors in Pulau Pinang	36
3.6	Number of Collection versus amount needed in Pulau Pinang	37
3.7	Donors by ethnicity in Malaysia	38
3.8	Donors by ethnicity in Pulau Pinang	38
3.9	Donors by gender in Malaysia	39
3.10	Donors by gender in Pulau Pinang	39
3.11	Roleo Therapeutic Arm and Hand Massager	40
3.12	The Hand Reflexology	40
3.13	Kinetec Maestra Hand & Wrist Machine	41
3.14	Kinetec Maestra Portable Hand Machine	41
3.15	Hand Held Massaging Tool	42
3.16	Hand-Held Massage Device	43

3.17	Message Machine, Massager for Hands and Massaging Method	44
3.18	Massaging Machine	45
3.19	Hand Type Electric Massage Machine	46
3.20	Respondents research	47
3.21	Percentage of respondents with experience and without in donating blood	50
3.22	Percentage for different blood types	51
3.23	Percentage amount of blood donated	51
3.24	Comparison blood amount collection	52
3.25	Reason for not donating	53
3.26	Blood donation process time	53
3.27	House of Quality project	54
3.28	Design Concept A	56
3.29	Design Concept B	57
3.30	Design Concept C	58
3.31	Sensoring Circuit	63
3.32	Simulation Circuit	63
3.33	First Stage Input Signal	64
3.34	Second Input Signal	65
3.35	Final Input Signal	65
3.36	DC Motor	67
4.1	3D Drawing and prototype models	70
4.2	Exploded View	70
4.3	Experience in Blood Donation	71
4.4	Effect after Blood Donation Process	72
4.5	Suitable Donation Time for 450ml	73
4.6	Acceptance Level for the Machine Development	73
4.7	Machine Design Perspective	74
4.8	Element Acceptance Level	74
4.9	Safety Aspect Consideration	75

4.10	Future Recommendation for Donor	75
4.11	Blood Donation Campaign	76
4.12	450ml Testing Respondent	77
4.13	450ml Donation Time	77
4.14	350ml Testing Respondent	78
4.15	350ml Donation Time	78

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Transfusable Blood Components	13
3.1	House of Quality Result	55
3.2	List of Concept Selection	60
3.3	Normal Range Heart Beat	62
3.4	Vibration Effect for Blood Circulation System	66
3.5	Temperature Effect for Blood Circulation	68
4.1	Prototype Costing	79

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
1	Research Permission Letter	87
2	Detail Drawing	94
3	Circuit Diagram	103
4	PIC Program	105
5	Gantt Chart	111

CHAPTER 1

INTRODUCTION

This chapter discusses an overview of the study conducted for the Master Project. Firstly, the background and the objectives are highlighted. Then, the statement of the problem and the scopes of the study are explained and followed by the organization of the thesis.

1.1 Background of the Problem

A blood donation process occurs when a person voluntarily has blood drawn and used for transfusion and/or made into biopharmaceutical medications by a process called fractionation (separation of whole-blood components). Blood banks often participate in the collection process as well as the procedures that required. In the developed world, most blood donors are unpaid volunteers who donate blood for a community supply. In poorer countries, established supplies are limited and donors usually donate blood when family or friends need a transfusion (directed donation).

The demand for blood is increasing as the population ages and new and aggressive surgical, oncological, transplantation procedures are introduced [1, 2] and as a result of greater use of blood products to treat medical conditions [3]. Besides the more severe donor selection criteria, the aging of population and low natality are the factors which influence the pool of potential donors and cannot be easily changed. Continuous

donor recruitment and retention are essential to maintain the nation's blood supply and to ensure the ability to meet future needs.

The volume of blood collected could be increased in two ways: by encouraging new donors to start donating, or by encouraging existing donors to donate more often, or both. The challenge for blood collection services is to devise strategies that encourage non-donors to make their first donation, to devise further strategies to reduce donor dropout, and to motivate behaviour change that will lead to committed regular donation. Establishing a reliable method of predicting who is most likely to donate blood would improve the likelihood of such strategies succeeding.

Normally the donor is given an object example a sponge or etc to be squeezed repeatedly. This activity generally increases the blood circulation and finally improves the donation process.

1.2 Problem Statement

Improving the amount of blood collected especially from new donors is the most critical issue in blood donation process. The challenge to encourage non-donors to make their first donation with reducing process time is strategies that can be implemented to motivate the community's especially confidence level during this process.

Below are some of the related questions to the above problems:

How the blood donation process can be improved by using a hand massage device.

What are the important needs to be considered?

What are the suitable concept designs to develop the device?

How to quantify the performance of the proposed design with several variables?

1.3 Objectives

The main objectives of this study are as follow:

- i. To design, develop and fabricate of a hand massage device for blood donation process.
- ii. To evaluate the performance of the prototype device.

1.4 Scopes of Study

This project focuses on the blood donation process.

- i. The respondents for this project are specific to the community in Malaysia only.
- ii. The proposed hand massage device operation is using vibration system with flexibility to control the amount of vibration to the body.
- iii. Quality function deployment (QFD) approach is used to indentify the customer needs before generating the design and prototype.
- iv. Criteria to develop the machine include durability, secure, reliability, optimum size, ease of use and handling.

The mechanism or conceptual design needs to be generated at the beginning. Then the best design concept was selected and tested as well as the analysis was conducted after the selection process. The analysis consists of identifying and quantifying the parameters that contribute to the improvement in blood donation process.

1.5 Organization of the Report

This thesis consists of five chapters. Chapter 1 covers the introduction of the study. Then, the literature review on related aspects of the study is discussed in Chapter 2. Discussion about research methodology is in Chapter 3 and followed by the result and discussion in Chapter 4. Lastly, Chapter 5 provides the conclusion and recommendation for the research.

REFERENCES

1. Judith Holdershaw, Philip Gendall and Malcolm Wright, Predicting willingness to donate blood, *Australasian Marketing Journal* 11 (1), 2003.
2. Natasa Vavic, Antonella Pagliariccio, Milica Bulajic, Maria Marinozzi, Glorija Miletic and Anka Vlatkovic, Blood donor satisfaction and the weak link in the chain of donation process, *Transfusion and Apheresis Science* 47 (2012) 171–177.
3. Kristina Cimaroli, Antonio Pa´ez, K. Bruce Newbold and Nancy M. Heddle, Individual and contextual determinants of blood donation frequency with a focus on clinic accessibility: A case study of Toronto, Canada, *Health & Place* 18 (2012) 424–433.
4. Elaine N. Marieb, *Essentials Human Anatomy and Physiology*, Pearson Education 2009.
5. Shannon Halpin, Case study: The effects of massage therapy on lumbar spondylolisthesis, *Journal of Bodywork and Movement Therapies* (2012) 16, 115-123.
6. Lucie Brosseau and George A. Wells, Ottawa Panel evidence-based clinical practice guidelines on therapeutic massage for neck pain, *Journal of Bodywork and Movement Therapies* (2012) 16, 300-325.
7. <http://www.fi.edu> (June 2014)
8. <http://www.redcrossblood.org> (June 2014)
9. <http://www.giveblood.ie> (June 2014)

10. <http://www.pdn.gov.my> (June 2014)
11. Mark A. Popovsky, Safety of RBC apheresis and whole blood donation in allogeneic and autologous blood donors, *Transfusion and Apheresis Science* 34 (2006) 205–211.
12. <http://www.medindia.net> (June 2014)
13. <http://www.malaysiablooddonors.org> (June 2014)
14. Virginia S. Cowe, Lee Burkett, Joshua Bredimus, Daniel R. Evans, Sandra Lamey, Theresa Neuhauser and Lawdan Shojaee, A comparative study of Thai massage and Swedish massage relative to physiological and psychological measures, *Journal of Bodywork and Movement Therapies* (2006) 10, 266–275.
15. Nuriye Degirmen, Nebahat Ozerdogan, Deniz Sayiner, Nedime Kosgeroglu and Unal Ayrançi, Effectiveness of foot and hand massage in postcesarean pain control in a group of Turkish pregnant women, *Applied Nursing Research* 23 (2010) 153–158.
16. <http://www.reflexology-uk.net> (June 2014)
17. <http://www.startherap-ease.co.uk> (June 2014)
18. Tiffany Field, Miguel Diego, Jeannette Delgado, Daniel Garcia and C.G. Funk, Hand pain is reduced by massage therapy, *Complementary Therapies in Clinical Practice* 17 (2011) 226-229.
19. Tiffany Field, Maria Hernandez-Reif, Miguel Diego and Monica Fraser, Lower back pain and sleep disturbance are reduced following massage therapy, *Journal of Bodywork and Movement Therapies* (2007) 11, 141–145.

20. Joanna M. Smith, S. John Sullivan and G. David Baxter, The culture of massage therapy: Valued elements and the role of comfort, contact, connection and caring, *Complementary Therapies in Medicine* (2009) 17, 181–189.
21. Peter Mackereth, Paola Sylt, Ashley Weinberg and Gwynneth Campbell, Chair massage for carers in an acute cancer hospital, *European Journal of Oncology Nursing* (2005) 9, 167–179.
22. Che Noriah Othman, Maryam Farooqui, Roz Azinur Che Lamina and Norina Din, Malay traditional massage therapy (MTMT) seeking behaviours among Malays for their chronic diseases-case study, *Procedia - Social and Behavioral Sciences* 50 (2012) 591 – 601.
23. <http://hubberzero.hubpages.com> (June 2014)
24. Karl Ulrich and Steven Eppinger, *Product Design and Development*, 3rd Edition, Mc Graw Hill/Irwin, 2004.
25. Jay Heizer and Barry Render, *Operations management sustainability and supply chain management*, 11 Edition, Global Edition Pearson, 2014.
26. [26]Health Informatics Center, Ministry of Health, Malaysia
27. State / District Data Bank Malaysia 2012 Report, Department of Statistics, Malaysia
28. Unit Transfusi Kesehatan, Hospital Pulau Pinang Malaysia
29. <http://www.massager-machines-and-more.com/roleo-arm-hand-massager.asp> (June 2014)
30. <http://www.hammacher.com/product/default.aspx?sku=81569> (June 2014)

31. <https://healthcare.fredstorey.com/product/kinetec-maestra-hand-and-wrist-cpm-machine> (June 2014)
32. <http://www.metmedicalcpm.com/cpmDevices.html> (June 2014)
33. <http://www.webmd.com/heart-disease/pulse-measurement?page=2> (June 2014)
34. Darryl J. Cochrane, *The effect of vibration exercise on aspects of muscle physiology and muscular performance*, Massey University Palmerston North New Zealand, April 2010.
35. <http://www.lusolarelectronics.com/lot-of-2-dc-5v-small-motor-dc-motor-2500rpm-hobby-for-fan-car-to-p-75.html> (June 2014)
36. H. Barcroft and O.G. Edholm, The effect of temperature on blood flow and deep temperature in the Human Forearm, *J. Physiol (1943) 102, 5-20*.
37. Joan McMeeken, Tissue Temperature and Blood Flow: A research based overview of electrophysical modalities, *Australian Journal of Physiotherapy 40th Jubilee Issue 1994: 49-57*.
38. M. J. Allwood and H. S. Burry, The effect of local temperature on blood flow in the human foot, *J. Physiol (1954) 124, 345-357*.
39. Julia C. McKay, Frank S. Prato and Alex W. Thomas, A Literature Review: The effects of magnetic field exposure on blood flow and blood vessels in the microvasculature, *Bioelectromagnetics 28:81-98(2007)*.
40. <http://www.esmartclass.com> (June 2014)
41. <http://www.anxietyuk.org.uk/> (June 2014)